POWER

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Lester Paige Breckenridge

WITH the completion of the present term, Lester Paige Breckenridge retires as head of the Department of Mechanical Engineering of the Sheffield Scientific School at Yale University.

For forty years he has been a teacher of mechanical engineering. "What a delightful experience!" he says, in relinquishing it.

Forty years of imbuing young men not only with the principles of mechanical engineering, but with the mental habits of the engineer.

Forty years of watching his boys, as he calls them, go out and win the places in the world for which his teaching has prepared them.

I never sat with him in a club or hotel or wheresoever men assemble, no matter how far from home, that he was not hailed a number of times through the meal or chat, by somebody passing through or who left his own table to come up and speak.

"One of my boys," would be the proud explanation as the caller walked away.

"A delightful experience," he may well say. A wonderful experience to have had a part in the remarkable development of engineering during the past twoscore years; to have been the "Breck" of thousands of its practitioners; to have served not only his school but his city and state, his profession and country, in many important associations and appointments.

We cannot imagine Professor Breckenridge as idle. He may retire to the green hills of Vermont in the summer, but he has "built him a house by the side of the road" up there and will continue to be an interested friend of man. He may go in the winter where, as he says, he "will not have to shovel snow or coal," but he is too dynamic not to continue to radiate suggestion and inspiration and to have an inductive interest in what is going on.

I have known him long, and that is a privilege. I have worked with him, and it has always been a pleasure. I congratulate him upon the completion of his twoscore years as an educator and wish for him a long term of physical fitness for the enjoyment of the leisure that he has so richly earned.

New Plant for Pueblo, Colorado

Initial 7,500-Kw. Unit of Modern Turbine Plant Installed—Special Coal and Ash Handling—Evaporator System for Make-up Water—Unique Method of Driving Circulating-Water Tunnel

SERVING five counties, in a territory southeast of the geographical center of the state, the Southern Colorado Power Co., a Byllesby property, has found it desirable to erect a new, modern plant at Pueblo. Tied in with the Mountain Division of the company to the northwest and the Valley Division to the southeast through a total of 344 miles of interconnecting high-tension transmission lines, the city is the natural center of distribution and of interchange between the 60- and 30-cycle services existing in the Valley Division and Pueblo, and the Mountain Division, respectively. A connected load approximating 50,000 kw. had been served mainly by a number of steam plants with comparatively small engine and turbine-driven units that were becoming antiquated.

In the Mountain Division, carrying about two-fifths of the load, the big generating station is at Canon City. It consists of a new 7,500-kw. turbine unit and 7,100 kw. in older engine- and turbine-driven generators, called upon in emergency only. The machines generate 30-cycle three-phase current at 2,300 volts, the station being operated steadily at fair load factor. Twenty-five miles north, in the famous Cripple Creek mining district, and at Victor are distributing stations, and on the third leg of the triangle, between Cripple Creek and Pueblo, a hydro-electric plant at Skagway contains two units with an aggregate capacity of 1,500 kw. This plant is operated to the limit of the water supply. The Canon City plant is called upon to carry the rest of the load in the division, and if need be, additional energy can be drawn from Pueblo. Between stations the energy is transmitted at 22,000 volts 30 cycles.

In the Valley Division a 60,000-volt transmission line extends from Pueblo to La Junta, a distance of about 65 miles It passes through Rocky Ford, where there is a reserve steam plant, and a number of other towns

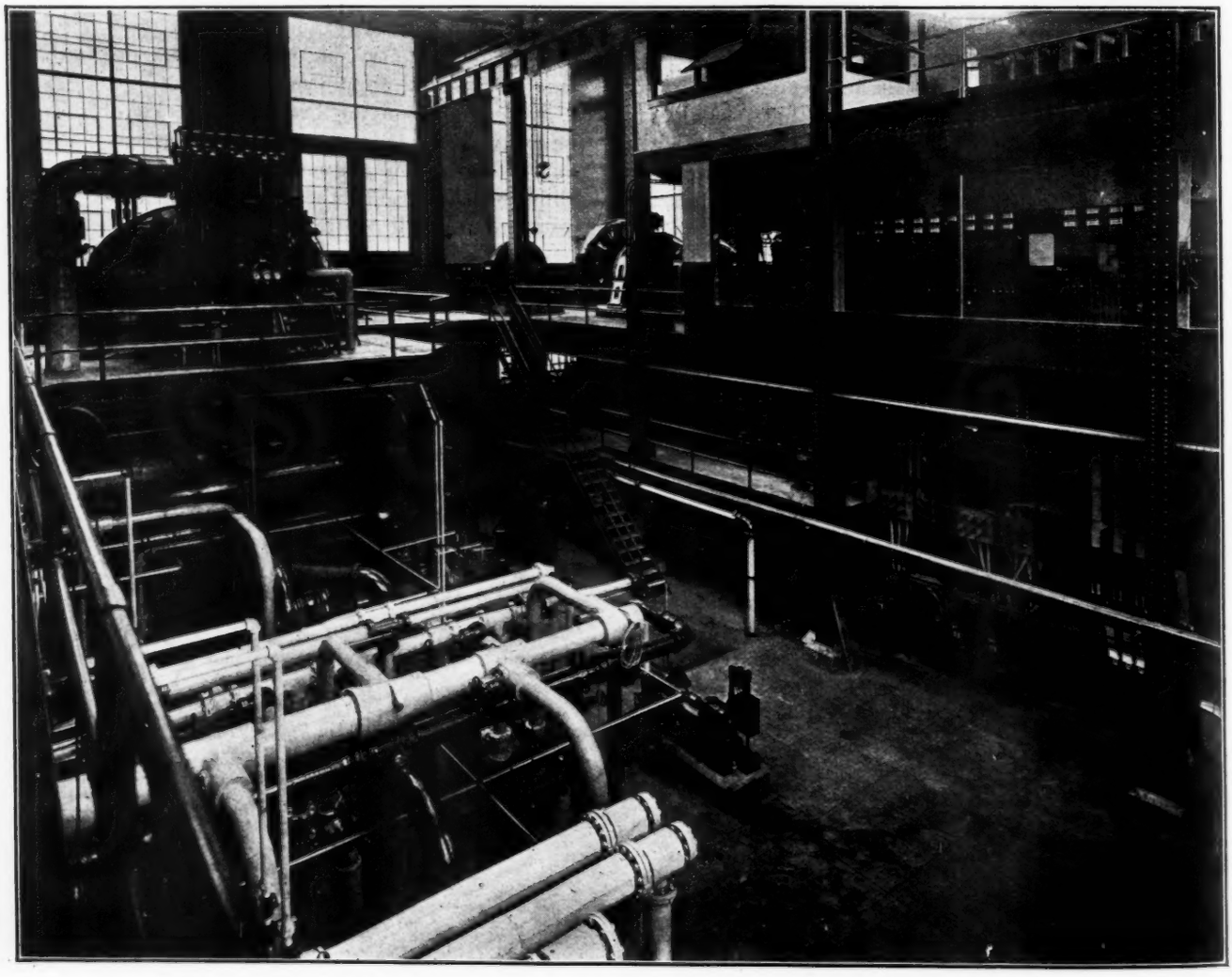

FIG. 1—TURBINE ROOM WITH ELECTRICAL GALLERY AT RIGHT, AUXILIARIES BELOW

FIG. 2—PLANT EXTERIOR SHOWING COAL AND ASH HANDLING

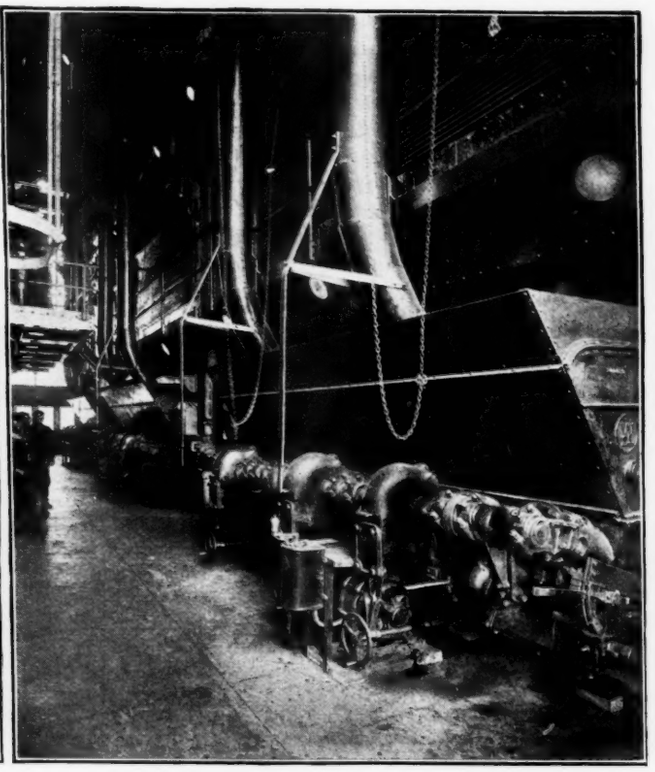

FIG. 3—VIEW OF BOILER FRONTS, SHOWING MOTOR AND STREET-CAR TYPE CONTROLLER

in the Arkansas River Valley, which is irrigated by extensive systems.

At Pueblo the older plant has a capacity of 3,100 kw. in 60-cycle generating equipment, 1,500 kw. in 30-cycle machines and 800 kw. in 600-volt direct-current generating units for street-railway service. In addition, a 2,000-kw. frequency changer and two 300-kw. motor-generator sets interchange the energy from 30 to 60 cycles or the reverse as may be necessary.

With economies in the older plants below present-day standards, generating capacity to serve the entire system becoming short and prospects for future growth favorable, it was decided to build a modern turbine plant at Pueblo in which improved economies in a comparatively short time would effect a saving sufficient to pay a large part of the capital investment. This plant was erected beside the older station with an initial capacity of 7,500 kw. in one unit, although ultimate plans call for two and possibly three units of the same size. The older plant will be retained for the present, and arrangements have been made so that the electric switching can be done from the new station. Three-phase 60-cycle current is generated at 2,300 volts to serve Pueblo and either of the outlying divisions as need be. The plan is to operate the new and more economical station continuously at a good load factor and call upon the older and less efficient plants to carry the peak. The new station is featured by special coal and ash handling, steam piping that has interesting points, an evaporator system for boiler makeup water and complete water systems for house service and cooling.

To supply steam to the initial turbo-generator, three boilers have been installed, each containing 8,201 sq.ft. of steam-making surface, or approximately 3 sq.ft. of surface per kilowatt of generator rating. The operating conditions are 230 lb. gage pressure and 200 deg. of superheat, giving a final steam temperature of 600 deg. F. The boilers are of the three-pass type delivering the gases of combustion vertically into a horizontal flue passing to a self-supporting steel stack of 14 ft. 2 in. inside diameter and 250 ft. in height above the boiler-room floor. The stack is lined with concrete to within 21 ft. of its base and for the remaining distance with firebrick. It is mounted on a structural-steel base tied in with the building steel.

The Colorado coal used in the plant, which is high in ash and moisture, is burned on underfeed stokers with nine retorts per boiler. They are equipped with steam ash dumps and are driven individually by 12-hp. induction motors of multi-speed design, operating at 1,800, 1,200, 900 and 600 r.p.m., respectively. As shown in Fig. 3, the motor is mounted in front on the boiler-room floor with its street-car type of controller immediately adjacent.

Forced draft is supplied by full-housing, double-inlet fans, one per boiler, directly connected to 85-hp. steam turbines. The speed is 1,600 r.p.m., and the capacity of each fan is 47,000 cu.ft. of air per minute. Although each fan normally supplies its individual boiler, there is cross-connection between fans to give flexibility and make it possible to use any fan to supply any one of the three boilers.

Coal is brought in at grade level and unloaded exterior to the boiler room into a track hopper. A reciprocating feeder delivers the coal through a 75-ton crusher to a continuous bucket carrier, making a continuous circuit under the hopper and over the end of the boiler room, the penthouse shown in Fig. 2 taking the upper horizontal run. From the pivoted bucket carrier transfer is made to a belt conveyor supplying the overhead steel bunkers of 125 tons capacity per boiler.

Large concrete, brick-lined hoppers receive the ash from the stokers. Through sliding gates, hand-operated by chains and gears, the ash is transferred into an in-

dustrial car which is pushed onto a micro-adjusted freight elevator to be raised bodily to the top of the elevator shaft for delivery to a concrete ash bunker supported over the coal track.

Coming from the Arkansas River, the water supply for the plant is muddy, containing large quantities of suspended matter and from 30 to 40 grains of scale-forming salts to the gallon. It is received in a large settling basin, and that portion of it to be used for general house service is filtered and stored in an overhead tank. At the same level is another tank for the storage

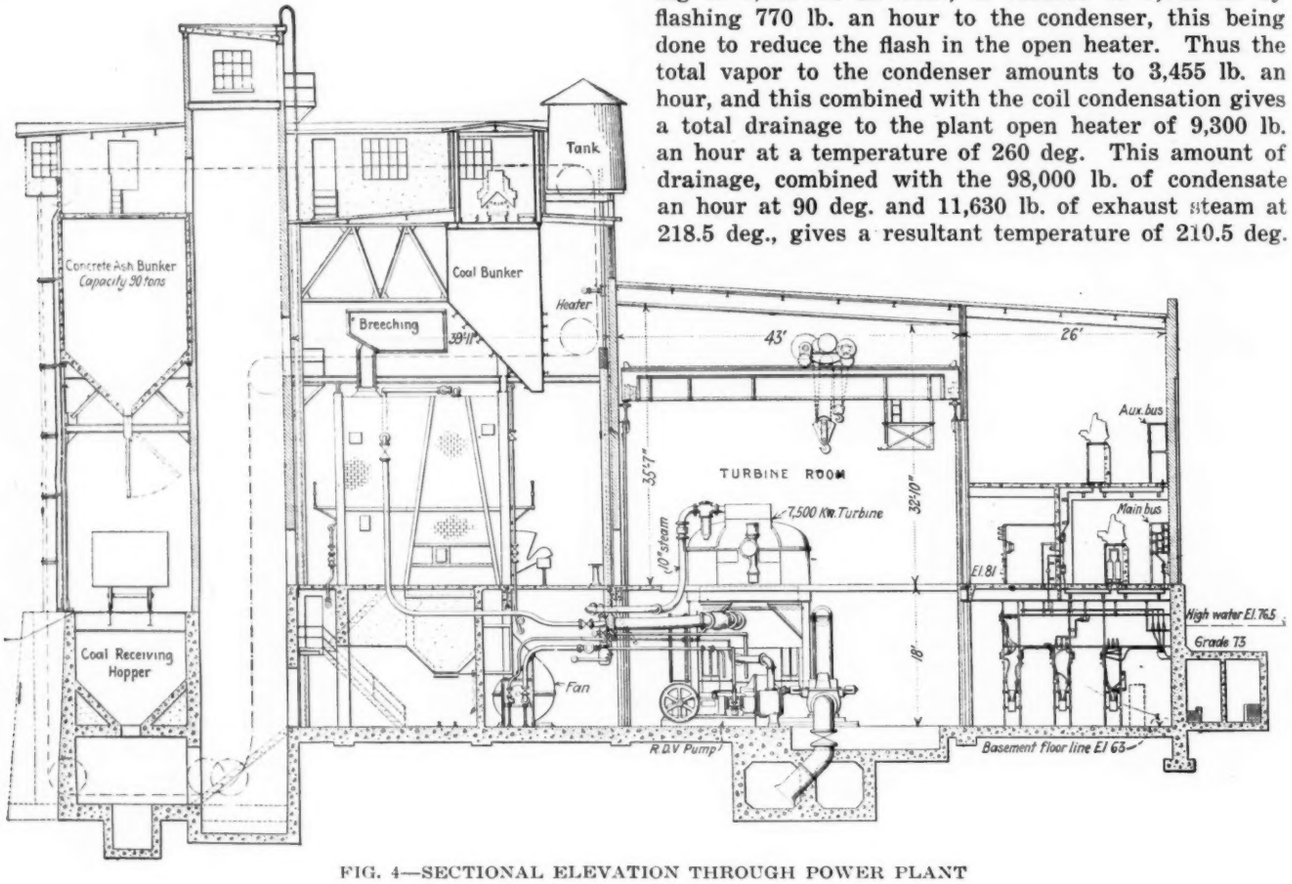

FIG. 4—SECTIONAL ELEVATION THROUGH POWER PLANT

of distilled water which is used primarily for the cooling of bearings.

For boiler feed the makeup water is passed through a high-heat level evaporating plant, having a net capacity to deliver 5,000 lb. of distilled water an hour.

To give an idea of the temperatures and quantities involved, it may be of interest to follow through the evaporator heat diagram, based on the conditions at the plant. Referring to Fig. 6, it will be seen that turbine condensate to the amount of 98,000 lb. an hour enters the plant open feed-water heater at a temperature of 90 deg. From the steam-driven auxiliaries, 12,300 lb. of exhaust steam at 2 lb. gage is divided between the plant heater and the open heater of the evaporator system. The latter takes 670 lb. of this exhaust steam an hour to heat to 210 deg. F. the 5,000 lb. of raw water entering at 80 deg. It is thus evident that 5,670 lb. of water an hour at the temperature indicated is drawn from the heater by the evaporator feed pump and forced to the first- and second-effect evaporators of the system, 2,985 lb. going to the former and 2,685 lb. of water to the second-effect evaporator.

To distill the water in the first-effect evaporator, 3,630 lb. of steam, dry and saturated, is drawn from the boilers, the connections being made back of the superheaters. The vapor from the first-effect evaporator, generated at 83 lb. gage and at the rate of 2,985 lb. an hour, passes into the coils of the second-effect evaporator, where in turn it evaporates 2,685 lb. of water an hour at 21 lb. gage and delivery is made to the high-heat-level condenser of the system. The coil drains from both effects lead down through traps to the plant open heater. The total drain from the two coils, amounting to 6,615 lb. an hour, is reduced to 5,845 lb. by flashing 770 lb. an hour to the condenser, this being done to reduce the flash in the open heater. Thus the total vapor to the condenser amounts to 3,455 lb. an hour, and this combined with the coil condensation gives a total drainage to the plant open heater of 9,300 lb. an hour at a temperature of 260 deg. This amount of drainage, combined with the 98,000 lb. of condensate an hour at 90 deg. and 11,630 lb. of exhaust steam at 218.5 deg., gives a resultant temperature of 210.5 deg. At this temperature the water is taken by the boiler-feed pumps and forced through the high-heat-level condenser to the boilers, the final quantity summing up to 118,930 lb. an hour.

With the boiler-feed water condensing the final vapor and flash in the high-heat-level condenser and carrying the heat absorbed to the boiler, the cost of distilling the water and providing scale-free feed amounts practically to the radiation loss.

Boiler-feed pumps are of the four-stage double-suction type, driven by 125-hp. steam turbines at a speed of 2,750 r.p.m. The water is delivered to the boilers under the control of pump governors and individual feed-water regulators. V-notch meters measure the total feed.

All high-pressure piping is of steel with cast-steel fittings and Cranelap joints. The layout of both steam and exhaust piping is shown in Fig. 5. From the three boilers, 7-in. leads drop below the boiler-room floor and are brought together in a special vertical fitting or manifold from which the 10-in. supply to the turbine is taken off. An auxiliary header supplies the smaller

steam-using equipment in the plant, such as the two boiler-feed pumps, three service pumps, the fan turbines, the rotative dry vacuum and hotwell pumps of the condensing outfit and one end of the double-drive exciter unit. In addition, there is a 3-in. saturated steam header to supply the evaporator system. It is connected to each boiler through 2-in. leads tapped in back of the superheaters. The exhaust piping from the various auxiliaries previously mentioned is brought together in a central vertical fitting from which the available supply is carried to either the evaporator heater or the plant open heater, the division being proportioned according to the requirements, as previously outlined.

The main unit, with a rating of 7,500 kw. at 80 per cent power factor, generates three-phase 60-cycle current at 2,300 volts. The speed is 1,800 r.p.m. At the throttle the steam-pressure is 225 lb. gage and the superheat 200 deg. F. For generator ventilation a special air washer has been provided and so arranged that it may be operated as a closed-air or a closed-water system. It has capacity to handle 30,000 cu.ft. of air per minute.

Immediately below the turbine is the surface condenser containing 13,000 sq.ft. of surface, or 1.73 sq.ft. per kilowatt of rating. It is equipped with a special

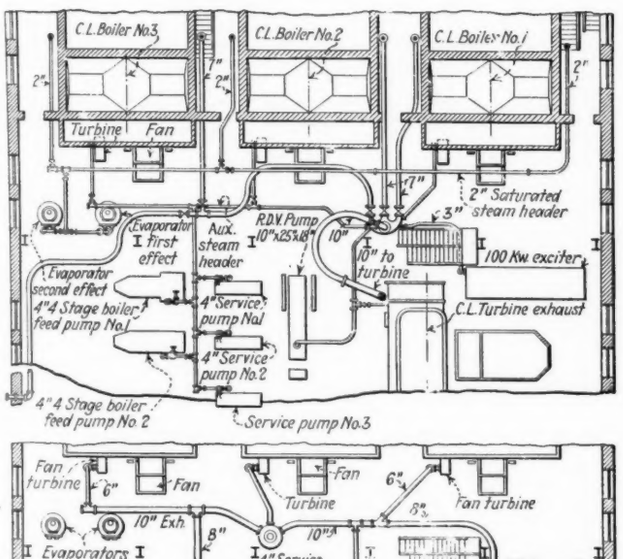

FIG. 5—PLAN OF STEAM AND EXHAUST PIPING

washer that will clean the surface while the unit is in operation, the muddy character of the water making such an installation practically desirable.

With the exception of the circulating pump the condenser auxiliaries are steam driven. The air pump is of the rotative dry vacuum type with cylinder 10x25x18 in. and a capacity to remove 8 cu.ft. of air a minute. The hotwell pump, a 3-in. two-stage centrifugal, capable of delivering 150,000 lb. of condensate an hour against a dynamic head of 85 ft., is turbine-driven. The circulating pump, with a 24-in. discharge, delivers 15,000 gal. a min. against a head of 22 ft. It is directly connected to a 150-hp. 2,200-volt induction motor, the speed being 450 r.p.m. With a condenser rating of 100,000 lb. of steam per hour and a circulating-pump capacity for the same period of 7,500,000, the water-steam ratio provided is 75 to 1.

The condenser cooling water is taken from and discharged back into the Arkansas River at a point

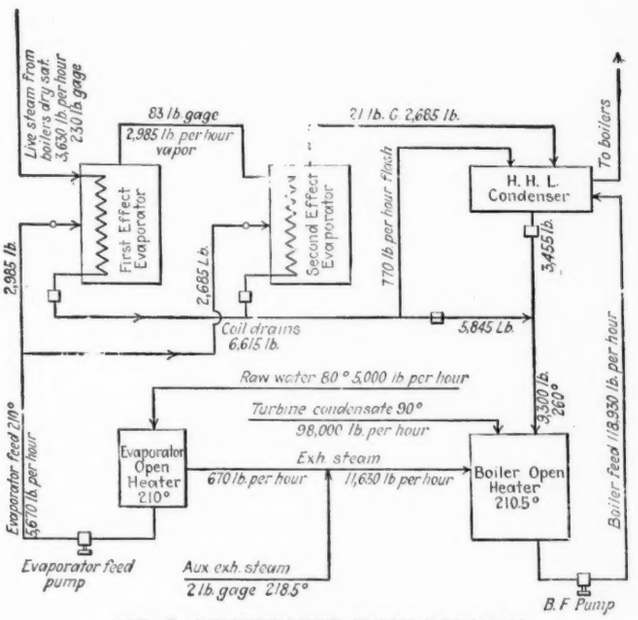
Live steam From boilers dry sat. 3,630 lb. per hour 230 lb gage
83 lb. gage
2,985 lb. per hour vapor
21 lb. G. 2,685 lb.
To boilers
First Effect Evaporator
Second Effect Evaporator
H. H. L. Condenser
770 lb. per hour Flash
2,985 lb.
2,685 Lb.
3,455 lb.
Coil drains 6,615 lb.
5,845 Lb.
Raw water 60° 5,000 lb. per hour
Turbine condensate 90°
98,000 lb. per hour
3,300 lb. 260°
Evaporator feed 210° 5,670 lb. per hour
Evaporator Open Heater 210°
Exh. steam
670 lb. per hour
11,630 lb. per hour
Boiler Open Heater 210.5°
Boiler feed 118,930 lb. per hour
Evaporator feed pump
Aux. exh. steam 2 lb. gage 218.5°
B.F. Pump

FIG. 6—EVAPORATOR HEAT DIAGRAM

approximately 260 ft. from the station through a two-compartment concrete tunnel. This tunnel is at an average depth of 28 ft. below the surface of the ground, 12 ft. below the low-water elevation of the river and is crossed by four railroad tracks, two of which are main lines—one the Santa Fe and the other the Missouri Pacific. Entrance to the tunnel is effected through a screenhouse at the river bank. It contains a revolving screen 60 in. wide and 33 ft. on centers. A stationary rack and drop-logs in front and back of the screen afford the usual protection.

Driving these tunnels entailed some interesting construction work. To avoid making an open cut under the railroad tracks, with the possibility of interrupting train service while the work was being done, a plan was worked out whereby the tunnel was made up in sections and driven through as a horizontal caisson. This worked out successfully on less than the estimated cost for the open-cut method. An open cut or shaft was made at the power-house end of the tunnel in which the sections were cast and driven toward the river. A similar shaft was put down at a point about halfway between the station and the intake at the river, and from this point the tunnel was driven in both directions. The material through which it was driven was a loose formation of gravel and sand with an occasional pocket of clay, the gravel varying in size from ½ to 4 in. in diameter.

Additional electrical equipment in the turbine room is a three-unit 100-kw. exciter set driven by a turbine on one end and a motor on the other. This is the only source of excitation at present, but if need be, it is possible to draw from the older station. The 2,000-kw.

frequency changer previously mentioned has been transferred to the new plant and additional rotary converters installed. This equipment may be seen at the end of the electrical galleries in Fig. 1.

As indicated in the sectional elevation, Fig. 4, the station has a double-bus system, main and auxiliary, from both of which connection is made to each of the three sections into which the feeder bus is divided. From one section of the feeder bus is taken three-phase power feeders, from another single-phase lighting feeders, and the third section is used normally for the station auxiliaries. Sectionalizing oil switches make it possible to tie the three sections together, and a transfer bus is provided so that the oil switches on any circuit can be cut out for inspection or repair, while maintaining service. The switches on these feeder circuits are of the solenoid-operated type. Overload relays are provided in all feeder circuits and balance relays on the main turbo-generator. The regulation on each lighting circuit is single-phase automatic.

Throughout, the construction is standard and the usual instruments are employed. The switching apparatus is arranged on three levels. On the lower floor are the feeder switches; on the second or turbine-room floor are the main bus, the respective oil switches and the control board. The auxiliary bus has been placed on the third floor. Following the general plan of using generator voltage on all motors above 50 hp., the circulating-pump motor and the exciter motor have been designed for 2,300 volts. For all other motors driving auxiliaries, the tension is stepped down to 220 volts.

The plant was designed and installed by Byllesby engineers, H. Boyd Brydon being responsible for the mechanical end and A. H. Tracy for the electrical work. George F. Phythian was in charge of the installation. F. H. Lane is manager of engineering and construction.

DATA ON PRINCIPAL EQUIPMENT IN PUEBLO PLANT

BUILDING DIMENSIONS

Length of boiler room, inside, ft	84
Width of boiler room, inside, ft	40
Distance basement floor to boiler-room floor, ft	18
Height from boiler-room floor to roof trusses, ft	36
Width of firing aisle, ft	12
Width of passage behind boilers, ft	5
Width of passages between boilers, ft	5
Ratio boiler heating surface to floor area	7.3 to 1
Turbine-room dimensions, ft	43x84
Distance basement floor to turbine-room floor, ft	18
Height, turbine-room floor to roof trusses, average, ft.-in.	34—2
Electrical gallery dimensions, ft.	26x84

BOILERS AND SUPERHEATERS

Manufacturer	Edge Moor Iron Co
Number of boilers	3
Type	Horizontal water-tube
Number of passes	3
Steam drums, four, outside diameter, in	35
Tubes	368 No. 9 gage, 20-ft. long
Heating surface, sq.ft.	8,201
Working pressure, lb. gage	230
Superheat, deg. F.	200
Steam temperature, deg. F.	600
Superheaters	Foster
Type	Single loop design
Surface, sq.ft.	600

STOKERS

Manufacturer	Westinghouse Electric & Mfg. Co.
Type	Underfeed
Number of retorts	9
Drive, induction motors, multi-speed design, hp	12

FORCED-DRAFT FANS

Manufacturer	Green Fuel Economizer Co.
Number installed	3
Type	Full housing, double inlet
Capacity, cu.ft. per min	47,000
Speed r.p.m.	1,600
Drive	Westinghouse tu.bine
Turbine rating, hp.	85

STACK

Type	Self-supporting Steel
Diameter at top:	
Inside of metal, ft.-in.	14—2
Inside of concrete, ft.-in.	13—6
Height above boiler-room floor, ft.	250

BOILER-FEED PUMPS

Manufacturer	Worthington Pump & Mach. Corp.
Number	2
Type	Four-stage, double-suction
Capacity, gal. per min	350
Drive	Terry steam turbine
Turbine rating, hp	125
Speed, r.p.m.	2,750

FEED-WATER HEATER

Manufacturer	Platt Iron Works
Type	Three-section, horizontal, open
Number	1
Capacity, lb. per hour	200,000

EVAPORATOR SYSTEM

Manufacturer	Griscom-Russell Co.
Type	High heat level
Capacity, net lb. per hr	5,000
Equipment:	
Reilly evaporators submerged type, Massillon evaporator open heater, four-pass high-heat-level condenser.	

SERVICE PUMPS

Manufacturer	Worthington Pump & Mach. Corp.
Number	3
Type	Double-suction Class "BS"
Capacity, gal. per min	400
Drive	Terry steam turbine
Turbine rating, hp	36
Speed, r.p.m.	2,750

WATER METERS

Manufacturer	Yarnall-Waring Co.
Type	Lea V-notch recording
Number	2
Capacity, lb. per hour	One 75,000, one 150,000

COAL AND ASH HANDLING

Peck Carrier, 24x24 in.	Link-Belt Co.
Horizontal centers, ft.-in.	61—6
Vertical centers, ft.	81
Operating speed, ft. per min.	60
Crusher	Link-Belt Co.
Capacity, tons per hour	75
Drive	Motor
Belt Conveyor	Robins Conveying Belt Co.
Size, in.	24
Centers, ft.	79
Speed, ft. per min.	220
Capacity, tons per hour	75
Drive	Motor
Ash car, two, 54 cu.ft.	Sackett Screen & Chute Co.
Elevator, 6,000 lb., 65 ft. per min.	Otis Elevator Co.

TURBO-GENERATOR

Manufacturer	General Electric Co.
Number of units	1
Steam at throttle:	
Pressure, lb. gage	225
Superheat, deg. F.	200
Rating at 80 per cent p.f., kw.	7,500
Generator	Three-phase 60-cycle 2,300 volts
Speed, r.p.m.	1,800
Air washer, Type "V"	Spray Engineering Co.
Capacity, cu.ft. air per min	30,000
Pump, centrifugal, 500 gal. per min	Goulds Mfg. Co.
Drive, induction motor, hp	10
Exciter, double-drive, 125-volt d.c. compound-wound,	General Electric Co.
Capacity, kw.	100
Drive, turbine, 150-hp	Terry Steam Turbine Co.
Drive, ind. motor, 150 hp. 2,200 volt	General Electric Co.
Condenser, surface	Worthington Pump & Mach. Corp.
Surface, sq.ft.	13,000
Capacity, lb. of steam per hour	100,000
Circulating pump, 24 in., 15,000 gal. per min., 22 ft. head	Worthington
Drive, ind. motor, 150 hp. 2,200 volt	General Electric Co.
Air pump, Laidlaw feather valve, 10x25x18-in.	Worthington
Hotwell pump, 3-in., two-stage, 300 gal. per min.	Worthington
Drive, turbine	Terry Steam Turbine Co.
Revolving screen, 60 in. wide, 33 ft. centers	Link-Belt Co.
Screen, washing pump, 3-in., two stage	Worthington
Drive, ind. motor, 20-hp. 220-volt 1,800 r.p.m.	General Electric

MISCELLANEOUS MECHANICAL EQUIPMENT

Traveling crane, 50-ton, three-motor	Niles-Bement-Pond Co.
Soot Blowers	Diamond Power Specialty Corp.
Valves and piping	Crane Co.
Safety valves	Consolidated Safety Valve Co.
Pump governors, Copes	Northern Equipment Co.
Feed-water regulators, Copes	Northern Equipment Co.
Steam traps	Crane Co.
Steam-flow meters	Bailey
Pressure gages	Ashcroft
Recording gages	Bailey
Draft gages	Bailey
Oiling system	Richardson-Phenix Div. S. F. Bowser & Co., Inc.
Pipe covering	Smith Totman Co.

MISCELLANEOUS ELECTRICAL EQUIPMENT

Main switchboard	General Electric Co.
Rotary converters, 400 and 750 kw.	General Electric Co.
Frequency changer, 60-30 cycles, 2,000 kw.	General Electric Co.
Transformers	General Electric Co.

The Development of the Hesselman Solid-Injection Oil Engine

BY EDVIN LUNDGREN

IN DEVELOPING his solid-injection oil engine, Mr. Hesselman tried out many different combustion-cavity designs, as well as different compression pressures until he finally arrived at the peculiar form shown in Fig. 1. The fuel is injected in such a way that the lowest parts of the fuel streams follow the slant of the piston top when the piston is in its highest position.

When ejecting the fuel into atmospheric air, the stream from each sprayer hole forms a cone, the sides of which include an angle of 15 deg., and it may reasonably be assumed that the spread obtained when injecting into compressed air does not materially differ from this.

Assuming that the sprayer is provided with five holes, it is evident, referring to the plan view in Fig. 1 *B*, that the fuel streams cover less than one-fourth of this surface. For this reason the fuel would not come into the required contact with the air unless special steps were taken to attain this result. An ideal manner would be to rotate the sprayer during the injection period, so that the fuel always would meet fresh air, but as such an arrangement, obviously, is impractical, the reverse method was chosen and the air is given a rotary motion in the cylinder. In a four-stroke-cycle engine this rotating motion is obtained very simply by shutting off one side of the inlet valve by a shroud *C* in such a manner that the air must enter

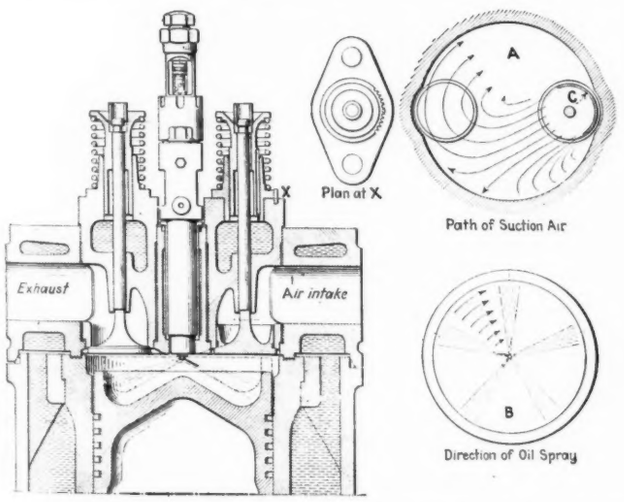

FIG. 1—COMBUSTION CHAMBER OF HESSELMAN ENGINE

in one predetermined direction, which is more or less tangential to the cylinder circumference, as show 'n Fig. 1 *A*.

Naturally, irregular turbulent motions and eddy currents in the entering air will occur, but these motions will to a great extent disappear during the compression stroke and only the desired regular rotating motion will remain. The velocity of this motion depends principally upon the position of the inlet-valve shroud.

Careful experiments have shown that a pronounced minimum fuel consumption is obtained at one certain position of the suction-valve shroud *C*. The results of these tests have been plotted in Fig. 2. It is very interesting to note that with the minimum shroud the fuel consumption was 30 per cent above the best results, and that with the highest obtainable velocity—that is, with the greatest amount of shroud—it was 15 per cent higher. In both these extreme cases the exhaust

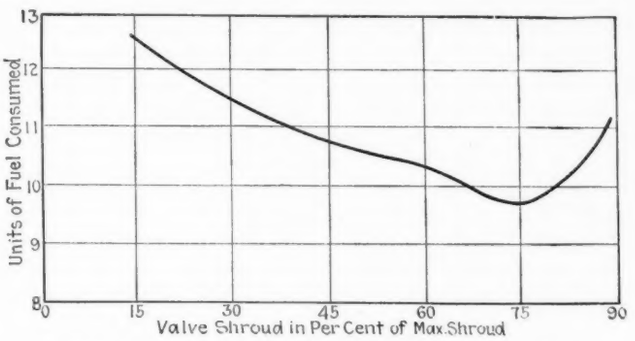

FIG. 2—INFLUENCE OF VALVE SHROUD UPON FUEL CONSUMPTION

gases showed a smoky color. The tests indicate that the most favorable air velocity is dependent upon the number of holes in the sprayer—the more holes there are the lower is the most favorable velocity. Evidently, the angular velocity must be such that the air passes the angle inclosed by two adjacent oil streams. As the injection takes place during approximately one-tenth of one revolution, and provided there are five holes in the sprayer, the number of rotations made by the air in the cylinder must be twice as high as the number of revolutions of the engine during the same time. The rotating velocity computed in this way remains within moderate limits and for the experimental engine is estimated to be 24 ft. per second.

Contrary to expectations the motion of the air does not in any way influence the timing of the ignition, but it exerts a marked influence on the shape of the indicator diagram, as with high velocity the expansion line falls rapidly even before the injection has ceased. The predetermined rotary motion of the air, as well as the special combustion shape, seems to effect the required intimate and rapid mixture of the fuel and the air in a more perfect manner than does the compressed air in ordinary Diesel engines.

The great value of the rotary motion is that it insures a relative motion of fuel and air even after the energy of the small oil globules has been exhausted. This contributes to the rapid propagation and the completeness of the combustion, as evidenced by the quick falling of the expansion line immediately after the close of the injection, by the low temperature of the exhaust gases and by the low end pressure, which in the experimental engine amounts to only 30 lb. gage at full load, the mean effective pressure being 76 lb. This is approximately 7 lb. less than that in a corresponding air-injection Diesel.

In the new engine, as with the majority of solid-injection engines, a comparatively low compression is used and dual combustion takes place; that is, part of the fuel is burnt at approximately constant volume with a certain detonation and an accompanying rise of pressure and temperature, which is very favorable to the second part of the combustion, which occurs at a fairly uniform pressure. Its indicator diagram represents a mean between the typical diagram of the Diesel and that of the standard gas engine.

Engine Compression Must Be High Enough to Insure Ignition

The compression must, of course, be high enough to assure ignition under all conditions, even when starting the cold engine. Since the cooling effect of the injection air of the Diesel engine is avoided, the necessary pressure may be less in the new engine than in the former. The experimental engine, having a compression of 400 lb. per sq.in., is easy to start, and it seems justified to assume that for larger engines a compression of 350 lb. would be sufficient. In the experimental engine a higher compression—namely 440 lb.—was tried, but without favorable results. In all likelihood the theoretical advantages of a higher compression are to a large extent offset by the greater resistance offered to the injected fuel by the air when compressed to the higher density.

The Hesselman engine was originally a standard four-stroke-cycle Diesel engine, rated as 65 b.-hp. at 300 r.p.m., having two cylinders with a diameter of 10 in. and a piston stroke of 14½ in. The air compressor was,

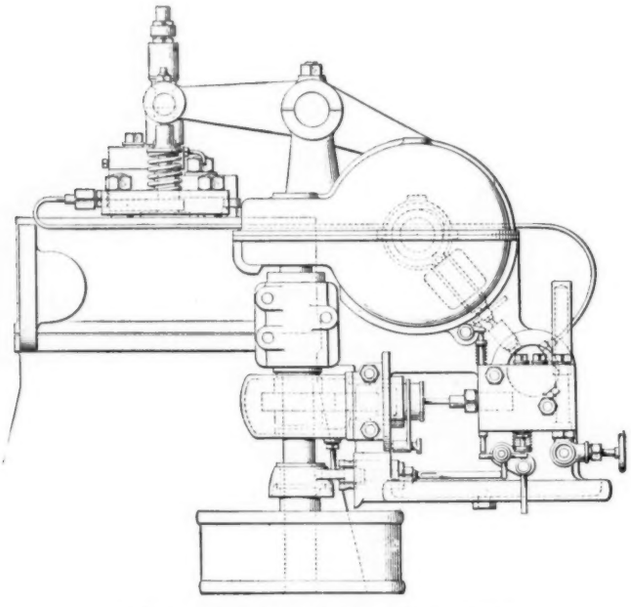

FIG. 3—EXPERIMENTAL FUEL PUMP

of course, put out of service and the cylinder heads and working pistons were replaced by new ones of another design.

The fuel pump used is shown in Fig. 3 and includes a cam-driven plunger having as many strokes as there were working strokes in the two cylinders; that is, one stroke per r.p.m. of the engine. The fuel is distributed to each cylinder by cam-operated distributing valves. The mechanical construction of the fuel pump must, of course, be adapted to the type of the engine that is to be equipped with the new injection system, and it naturally may show a great many variations.

To insure reliable service, the fuel is supplied to the fuel pump by means of a special feed pump which forces the fuel through a high-pressure filter of an original and simple design. The fuel enters the lower chamber of the filter and is led into longitudinal grooves cut into the circumference of a solid cylindrical centerpiece which fits into the filter casing with a very fine clearance. The oil must pass through this clearance in order to get into another alternating group of longitudinal grooves leading to the discharge end of the filter. In this way no matter thicker than 0.001 in. is allowed to pass. The filter is of the same design as the one shown attached to the fuel valve in Fig. 4 at *C*.

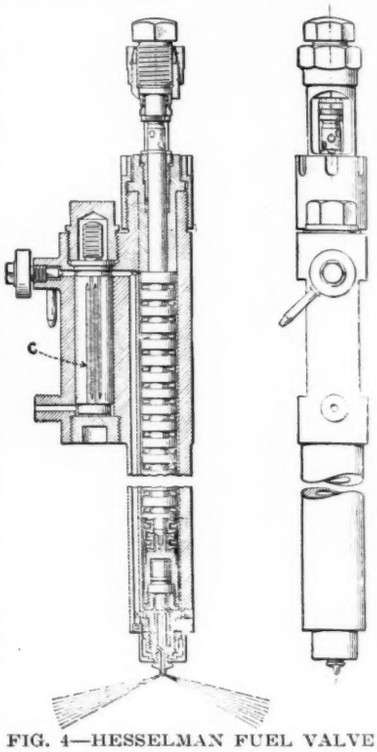

FIG. 4—HESSELMAN FUEL VALVE

Clean fuel is a necessity for any oil engine, but for an engine working with solid injection it is a question of vital importance in view of the small openings through which the fuel must pass. The total straining area of the filter is, on account of the length of the grooves, very large and therefore the filter may with ordinary fuel oil, serve a long time before it is clogged up. A second filter may be switched in when the first one is removed for cleaning, which is done as soon as the pressure gage near the feed pumps indicates that the resistance of the filter becomes too high. The filter may be cleaned in a few seconds.

Fuel Valve Design

The fuel-valve spring is of a unique and extremely compact construction and therefore deserves a detailed description. It is composed of a number of elastic spring elements, as shown in Fig. 4. Each spring element may be described as consisting of two disks turned on a short cylinder. The hole of the disks or the inside diameter of the cylinder is of a certain size which a mathematical investigation and practical experiments showed to give a maximum deflection. Two adjacent spring elements or double disks are connected to each other by means of shrunk rings and separated from each other by annular distance pieces. By adding more or less spring elements to each other, springs of different lengths and qualities may be obtained. The double disks can easily be made in a turret lathe and are then ground to a light force fit in the shrunk rings. The spring in the experimental engine had an outside diameter of 1¾ in. and, when fully compressed, exerted a force of 1,800 lb. upon its seat. It would be difficult to design a coil spring of the same dimensions, possessing the same stiffness.

The compression of the spring is adjusted by means of a nut on top of the valve and by the valve spindle, which passes through a packing of suitable material. The spring spindle, once adjusted, stays stationary, and it offers, therefore, not the slightest difficulty in keeping the packing tight. The lower end of the spring is connected to the needle valve which, like the valve seat, is made of hardened steel in order to sustain the high pressures without any wear or deformation.

As soon as the pressure of the spring, normally about 3,500 lb. per sq.in., is overcome, the fuel valve opens and permits the fuel to enter the nozzle and through the fine holes of the sprayer, to be sprayed into the cylinder above.

Advantages of Hesselman Fuel Valve

The main advantage of this valve construction is its entire freedom from friction, which enables the valve to open in exact proportion to the effective stroke of the fuel pump or, in other words, to the amount of fuel delivered, which in its turn corresponds to the momentary load.

In comparison with a mechanically operated valve the design described has, like any automatic valve, the advantage of a simpler construction, and it may be placed in any position, as there is no layshaft or valve gear to be taken into consideration. The construction of the spring, as well as that of the filter, the various features and the principles of the fuel pump and also the principle of the rotating motion of the cylinder air are thorougly protected by patent applications in all civilized countries.

The results of official tests carried out under the supervision of Professor Hubendick, of the Technical

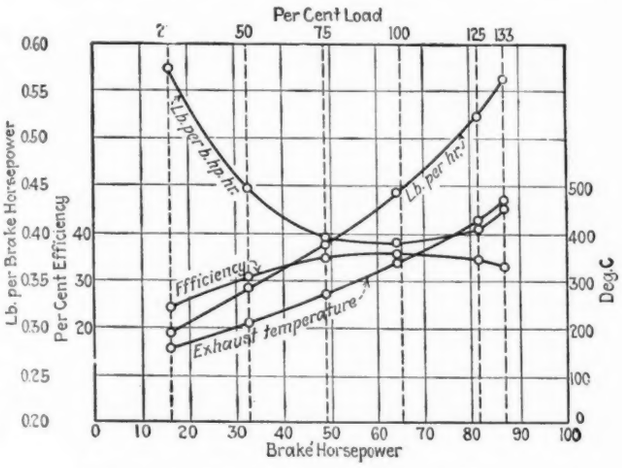

FIG. 5—TESTS OF HESSELMAN OIL ENGINE

University of Stockholm, and in the presence of the writer, are shown graphically in Fig. 5. The load was applied by means of a Heenan & Froude hydraulic dynamometer. The fuel consumption at full load was 0.39 lb.; at ¾ load, 0.397 lb.; at ½ load, 0.445 lb.; at ¼ load, 0.575 lb. per brake-horsepower. At 25 per cent overload it was 0.404 lb., and at 33 per cent overload it amounted to 0.427 lb.

The remarkably high overload carried by the engine deserves particular attention, the more so as the exhaust gases remained perfectly clear and colorless (even when using boiler oil as fuel), this, in connection with the low fuel consumption, indicating complete combustion. At 33 per cent overload the mean effective pressure amounted to 105 lb. per sq.in.; at the rated load of 65 brake horsepower this pressure was 76 lb. Fig. 6 shows a normal and an offset indicator diagram.

As already mentioned, these results, obtained with an experimental engine of a comparatively small size,

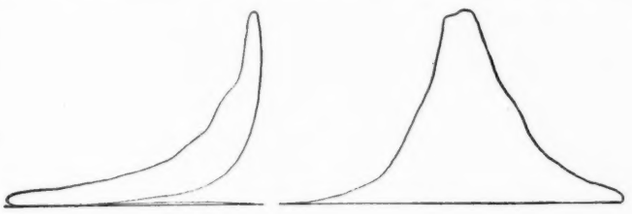

FIG. 6—INDICATOR DIAGRAMS TAKEN DURING THE TESTS

must be considered as very good and seem to justify the considerable experimental work expended in the attempt to design a new rational solid injection engine.

What Constitutes a Good Coal Specification?

By Russell G. Paddock*

About twenty years ago the first specification for the purchase of a large order of coal was used. The purpose of this specification, as well as all succeeding ones, was to obtain an agreement between the buyer and seller as to the true quality of the coal to be furnished and some legal means for enforcing the agreement. The plan gradually grew in favor, and in 1906 some of the departments of the United States government adopted it and now purchase much of their coal under specification. At the outbreak of the World War over ten million tons of coal annually was being purchased in the United States by this method. Owing to changes in the market conditions and coal shortages during and since the war, the plan has been practically discontinued. The unsettled conditions have enabled the operators and dealers to dictate terms to the buyer, who has been thankful to receive coal of any quality in order to keep his plant running. But as times become more settled and the law of supply and demand becomes operative again, the buyer, at least, will favor the specification method of purchasing. It might be well, therefore, to note briefly its advantages and disadvantages and to outline points that should be covered in a proper specification.

The following advantages are claimed for the specification method:

1. It brings about a definite agreement between the buyer and seller as to the quality of the fuel to be furnished.

2. It insures the buyer a more uniform fuel and he is led to make a careful study of the operating conditions of his plant to discover the possibilities of additional economies.

3. Operators will be more careful in the mining and cleaning of the coal.

4. Competition is broadened and all sellers are placed on a logical and equitable basis.

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5. In case of variation of the fuel from the contracted standard, adjustments of price are readily made.

6. The buyer pays exactly for the useful heat delivered regardless of whether it may be above or below the standard. The penalty and bonus plan is fair for both parties.

Opponents of the plan claim the following disadvantages:

1. The seller is placed at a disadvantage for the sampling, and analysis must obviously be done by the buyer.

2. If greater care is to be taken in the mining operations, the costs will inevitably be greater.

3. The cost of sampling and analysis is considerable and may offset the possible gains.

4. It is unfair to require the operator to guarantee qualities of product which are often beyond his control.

5. There are in coal so many variables that influence the final usefulness and economy that it is practically impossible to cover all points in a specification that is fair to both parties.

There is undoubtedly some basis for these objections, but it seems that the advantages of the specification method overbalance the objections. In most cases where the system has been tried and accurate records have been kept, considerable economies have been effected without particular hardship to the seller.

What Should Be Included in the Specification and How Should It Be Prepared?

First of all the specification should be as simple as possible and should cover only the absolute essentials for defining the required product and assuring its uniformity. One of the basic defects of many specifications has been that they have been so formidable in their provisions as to make many sellers doubtful about entering into a contract, and often the seller has added enough to the bid price to cover the possibility of any penality that might be exacted. In this way the specification has defeated one of its main purposes.

The operating conditions of the plant should be studied carefully and the essential qualities of the fuel to be used should be determined. The location and distance of the plant from the sources of supply must be taken into consideration, for freight rates may even be the determining factor in the final choice. The ultimate aim is to obtain the greatest number of heat units per dollar, delivered to the steam. This dollar must include cost of coal, labor costs, maintenance costs and investment costs, and account should be taken of the hazards of storage. After the plant requirements have been carefully studied, the fuel requirements should be incorporated into a tentative or approximate specification upon which to solicit bids from any desirable sources.

The features pertaining to the quality of the coal, which should be covered in the preliminary specification, in addition to the general grade of coal desired, are those that are under the control of the coal-mine operator and those that seriously limit the usefulness of the coal in the particular plant. These are the total ash (dry basis), moisture content and the minimum fusing temperature of the ash.

When the bidder specifies the vein and mine from which the coal is to be shipped, the normal moisture, inherent ash and the B.t.u. value are fairly well fixed and will not vary enough to warrant including in a specification. But the variation of the total moisture from the coal-bed moisture depends upon the methods of cleaning and shipping. The extraneous ash, also, is largely under the control of the operator, and he should be penalized or given a bonus depending upon the care he takes to furnish clean coal. The specifying of the minimum fusing point of the ash implies a knowledge on the part of the seller of the combustion properties of his coal, and he should not bid if he cannot guarantee this point. Variation in this respect below the minimum should be grounds for rejection. As a standard for checking the uniformity of the coal and for taking into account any moisture variation, the buyer may specify the heat content "as received," for, other factors being equal, that is what the plant manager is buying and what the operator or dealer is selling. Therefore, the quality of the coal is sufficiently specified if the B.t.u. content "as received," total ash (dry basis), and the minimum fusing temperature of the ash are covered.

Other points to be covered in the specification are the period for which the contract is to be let, the approximate amount of fuel required, the place and time of deliveries, causes for the rejection of fuel and the cancellation of contract, methods of sampling and analysis, and the method of figuring price adjustments due to variation in the heat content or ash content. The provisions for price adjustment should be based equitably upon the total loss the buyer would suffer or the savings he might effect if these items are above or below the standard. These provisions will differ for each individual case.

After the bids are received they should be carefully considered, the best one provisionally accepted and a limited amount of the coal purchased and subjected to actual service test before the contract is signed. If the coal supplied is found to be satisfactory on the test, the qualities guaranteed by the bidder should be adopted as a basis upon which to figure price adjustments.

Such a basis upon which to compare the uniformity of the fuel is fair to the seller, for it is his own standard, and it has been shown by test to be satisfactory to the buyer. There is no reason, therefore, if the provisions of the specification are carefully followed, why the operator will not have a satisfactory market for his product and the plant manager will not be able to effect definite savings by being assured of a fairly uniform fuel which he can burn to the best advantage.

An Omission

The account in the May 1 issue of the installation of powdered-fuel equipment by the United Electric Railways of Providence failed to mention that the system used was the Lupulco and that the arrangement adopted was the result of the co-operation of the engineers of the Combustion Engineering Corporation, which has developed that system, and the engineers of the United Railways Company. The oversight was not due to any lack of appreciation of the large way in which the engineers of the Combustion Engineering Corporation have attacked the problem of burning powdered coal through the scientific analysis of results obtained in large-scale operation and the leading part that the corporation has taken in the recent phenomenal development of this method of using solid fuel.

In riveting nozzles to boiler drums, it is desirable to use as small a diameter of rivet circles as can be made in a practical manner, as this represents a stronger drum construction than that of a wider rivet circle.

Steam-Turbine Governors and Valve Gears —Additional Causes of Hunting*

By EUSTIS H. THOMPSON†

STEAM-TURBINE governors are usually adjusted to allow a drop in speed of 2 or 3 per cent from no load to the full load valve opening. A close regulation, such as 2 per cent, is often desirable in alternating-current turbo-generators. This tends to keep the speed of the generators, and hence the frequency of the system to which they are attached, more nearly constant; there is less variation of frequency when the load changes than with a wider governor regulation.

A broad regulation, on the other hand, assists the mechanical governing operation. Conditions that would cause apparent hunting with close regulation, such as an excessively large mass in the levers moved by the governor, do not always cause hunting at increased regulation. The problem in power stations sometimes resolves itself into adjusting the governors to give as close a regulation as possible without undesirable valve-gear surging. Most commercial turbines will operate satisfactorily with as short a governor regulation as 2 per cent representing the drop in speed from no load to full load. If this were shortened to 1 per cent, or less, however, few governors would give satisfactory operation. This is because the turbine would drop only about half as much in speed when a load is applied in order to give the required valve opening. The governor would have, therefore, approximately half as much time for regulating the valve. Even with the small governor corrections that are required with the machine running at light load, it is probable that hunting would occur at 1 per cent regulation adjustment, and certainly at ½ per cent.

HUNTING is readily caused by excessively short regulation, too great a mass in the lever or other parts to be moved by the governor; or the admission by the valve gear of an abnormal amount of steam in proportion to governor movement. This article discusses hunting as produced by each of these causes. Some special troubles met with in certain types of valve gears will be taken up later. Discussions or experiences are solicited from those interested in the steam turbine.

If the no-load speed of a turbine is 1,836 r.p.m. with a 2 per cent regulation, indicated in Fig. 1, the speed at quarter load would be approximately 1,827 r.p.m. If the governor flyballs have an effective weight of one-quarter pound each, acting at a radius of 2¼ in. at no load and 2 in. at one-quarter load, we would have a pull exerted by the weights at 1,836 r.p.m. of approximately 113.767 lb., using the approximate formula,

$$F = 0.00003\ WRN^2$$

where

F = pounds centrifugal force, —
R = inches effective radius;
W = pounds effective weight;
N = revolutions per minute.

The pull at 1,827 r.p.m. is 100.138 lb. The difference of forces acting on the governor is 13.63 pounds.

Now if the regulation is reduced to 1 per cent for full load, keeping the same no-load speed, the speed at one-quarter load will be 1,831½ r.p.m., where the weights will exert a force of 100.631 lb. The effective force on the governor is 13.136 lb., which is about 3½ per cent less than the force acting with the 2 per cent regulation. The difference in acting force is therefore negligible. The hunting action is caused by the governing movement lagging behind the speed change. In regard to the time element the turbine slowed down 9 r.p.m. from no load to one-quarter load with a 2 per cent regulation; the machine slows down, however, only 4½ r.p.m. when one-quarter load is applied at 1 per cent regulation. It will, therefore, take approximately half as much time to reach one-quarter load speed with 1 per cent regulation, while the flywheel or kinetic energy is being given up.

If the governor is just fast enough to handle one-quarter load with a 2 per cent regulation, it will evidently be too slow in opening the valve with a 1 per cent regulation, on a similar load. Normal variations which take place suddenly are seldom as much as one-quarter load in ordinary plants. Governors usually have plenty of leeway as to power available for correcting the valve under normal conditions of operation. Cutting the time element in half, however, would probably require more than the reserve force of ordinary governors, so that hunting would probably exist, especially with the machine at light loads.

When the governor cannot adjust the steam valve in the required time, the speed will be much lower than one-quarter load speed when the valve finally reaches one-quarter load position and consequently checks the slowing up of the turbine. On account of this lower speed at one-quarter load there is a tendency for the governor to continue to exert force tending to open the valve after the speed is checked. This would cause the valve to overtravel and open more than one-quarter load position. In reversing the speed there may be overtraveling again, so that this governor condition inclines to set up a continuous oscillating and overtraveling movement.

The hunting becomes worse if the speed of the turbine is raised, as this tends to shorten the regulation. There will thus be still less time for governor movement than before.

It is sometimes necessary to dismantle a governor for repairs or to inspect other parts of a turbine. In doing this with some types of governors, it is quite easy to twist the plug on which the governor spring is screwed, when the governor is disassembled, so that more active turns are placed in the governor spring than before. Consequently, a closer regulation will result, after adjusting to no-load speed. Hunting may occur in such a case and will vary with the changes of speed as described. The no-load speed will now be higher if the

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governor spring is in compression, increasing the sensitiveness to hunting. When the governor spring is in tension, the turbine speed would be lower, if the spring became unscrewed from the plug. The regulation would not be closer until the governor spring was adjusted to normal no-load speed.

Excessive Mass of the Parts To Be Moved by the Governor Produces Hunting

In connection with hunting caused by abnormally close regulation, the condition of excessive mass should also be mentioned. When a change of load occurs, the governor must move the valve in accordance with the change of speed or fairly close to the change of speed. If the moving parts such as levers, links, etc., are too heavy for the governor spring to move easily, we will have overtraveling of the valve similar to that caused by abnormally close regulation.

Well-designed governors and valve gears do not have abnormally large masses to be moved by the governor spring. Excessive weight, indicated at *A*, Fig. 1, would cause hunting. This condition is practically never encountered in ordinary practice. In some special cases where compensating levers or other auxiliary devices are attached to the moving element, a state of excessive mass may be produced. It sometimes happens, on account of the failure of the synchronizing spring, that a heavy weight is attached in connection with the valve gear as a substitute force for obtaining the proper speed. This condition may cause surging.

Hunting of this kind is likely to be very puzzling in character, as the valve gear can be put in absolutely perfect adjustment and still overtraveling will exist. A good method for determining the cause of hunting is to broaden the regulation just enough to give the governor spring a comparatively greater time element and thus produce better governing adjustment. Now, if the governor is speeded above normal by increasing the tension on the governor spring itself, this condition of hunting will again appear, showing that it depends on increase of speed. Hunting due to other causes is not affected to this extent by changes of speed. When hunting can be produced by increasing governor speed from 5 to 10 per cent, excessive mass is the most likely cause, provided regulation is normal.

Excessive Steam Admission in Relation to Governor Movement Will Cause Surging

Imagine that a light load has been added to the turbine and instead of the valve opening a corresponding small amount, it has opened a very large amount, possibly three-quarters of full opening. The turbine would now speed up rapidly until the valve has closed to the proper opening. The natural time of the governor movement may have been too slow to close at the proper speed, as the valve travel would usually lag a small amount under any circumstances. With the abnormally quick rise in speed the valve will lag more. This will require a drop of speed in order to correct the valve opening, and on account of the amount of overtravel that has already taken place, the valve may not correct it properly even at this reversal. A hunting action will therefore be set up, especially noticeable with a changing load.

A similar condition may occur in case the steam pressure becomes boosted up abnormally. Turbines occasionally receive steam from reducing valves. Abnormal conditions may arise and possibly double the rated steam pressure at the valve element. Surging would then occur principally at light load where the largest relative amount of steam is admitted for a given amount of travel. Improper adjustments in the case of valve gears containing multiple valves may cause more valves to open at one time than required, producing excessive steam admission and therefore hunting.

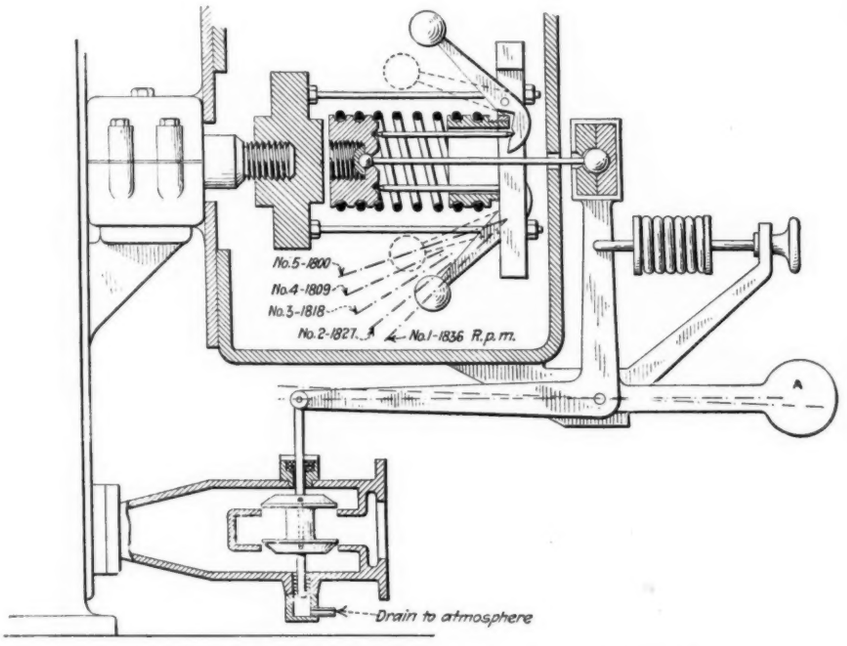

FIG. 1—GENERAL PLAN OF DIRECT ACTING GEAR

The steam valves of direct-connected governors are practically always of the balanced type. The valve in Fig. 1 may become unbalanced if the drain to atmosphere becomes closed. In this case a pressure will be exerted on the bottom of the valve steam, tending to hold the valve open.

Unbalance of the valve may cause pulsations and set up oscillations of the valve gear. Valves are sometimes encountered that produce unbalanced pressures at certain points of opening due to defects of workmanship, wear, or equalizing ports. This in turn may result in rapid vibration of the valve. Noise and vibration in the valve itself are noticeable in such a condition. Such oscillation may wear shoulders on the valve stem and cause the valve to stick in one position. Hunting of a fairly slow period similar to that caused by friction will result.

Surging of direct-current valve gears is usually due to friction or wear. A convenient way to locate such trouble is to move as much of the valve gear as possible by hand in order to detect any sticking, binding or lost motion. In Fig. 1 the bell-crank lever can be moved to see if there is any lost motion. If not, the transmission bearing may be removed or loosened and the bell-crank lever moved by hand to test it for friction or binding.

If this is free, the governor should be inspected for signs of rubbing by the moving parts. The steam valve may stick on heating up. It would be well, therefore, to investigate the machine while it is still warm, or at the time the trouble occurs.

On the valve gear, shown in Fig. 2, it is most convenient to check up the whole line of governor links by loosening up on the governor spring and moving the governor weights by hand. Sticking or binding would ordinarily be looked for in the bearings, packing or valve.

Running away at no load is a trouble at times experienced. This is usually due to improper adjustment of the governor and valve so that the latter fails to close

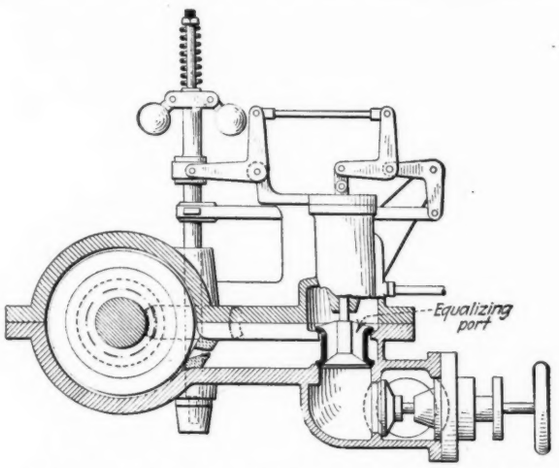

FIG. 2—FLYBALLS EASILY MOVED BY HAND SO AS TO DETECT FRICTION OR LOST MOTION

properly, or it may be due to wear in the valve or seat, so that it does not close properly. Sometimes lost motion in the governor-transmission bearing is responsible. The valve may develop sticking at light loads in sufficient amount to prevent its closing.

Turbines occasionally fail to carry overloads. This may be due to wear or misadjustment which prevents the governor from opening the valve sufficiently, and also may be caused by turbine troubles such as blade erosion or collection of dirt or impurities in the steam passages of the turbine or piping, particularly the steam strainer.

Unbalance of the valve may cause overspeed, low speed or failure to carry load.

Summary

Hunting may be caused by excessively close regulation of the governor. Adding one-quarter load will then produce fewer revolutions drop in speed for the required valve opening than before. The governor will then have less time to do its work, which may cause an excessive lag behind the speed change and thus set up surging.

Excessive mass of levers and other parts to be moved by the governor may also increase governor lag to a point where undesirable hunting exists.

The admission or restriction of too great an amount of steam, in relation to governor movement may produce excessive speed variation. Surging, therefore, may result when the speed changes become too fast for the governor to correct.

Unbalanced thrusts or pulsation set up by steam valves or other elements in a valve gear may cause governor surging.

Efficiencies of Old Reaction Wheels Improved by Rubber Seal Rings

Since the advent of rubber seal rings for reaction-type waterwheels the idea of fitting such rings to old units to improve operating conditions has been tried out successfully in a number of Western plants. These rings can be installed to good advantage, it is claimed, when a unit has fallen off in efficiency after long service due to seal ring leakage or where sediment in the water makes necessary frequent renewal of the ordinary metal seal rings. The rubber seal rings developed by E. C. Hutchinson of the Pelton Water Wheel Co. were described in *Power*, Dec. 26, 1922, p. 1014.

Based on the operating experience in Western plants, it is stated that under hard wearing conditions the rubber seal rings will last longer than metal and will also keep water leakage and resultant efficiency loss to a minimum without any danger of internal rubbing or damage. There is no means of figuring exactly the improvement in operating conditions that may be expected from the use of rubber seal rings in old turbines. However, in all cases where they have been put in old units the increase in efficiency and turbine capacities is said to have made the first cost of the improvement a highly satisfactory investment.

On one California plant, for example, which has been in service more than ten years, the turbine, when new, developed 1,550 kw. with a depth of 37 in. of water in the canal supplying the forebay. After years of wear without renewal of seal rings, the output dropped to 1,440 kw. with the same depth of water in the canal. Rubber seal rings were then installed and the turbine output was thereby increased to 1,670 kw., using the same amount of water. This capacity, however, was too great to be carried continuously on the generator, and the quantity of water admitted to the turbine was reduced to keep the power within limits safe for the generator. The surplus water was then used to operate an old stand-by unit for which no water supply had previously been available. This unit is now delivering 110 kw. and the main unit 1,550 kw. with the same 37-in. depth of water in the supply canal.

In this case, as in most cases of putting the rings in old units, the change is quite simple and involves only the removal of the existing all-metal wearing rings or sealing rings and the substitution of the rubber rings. Usually, this is done without other modification of the unit. The present construction of the seal rings, particularly for high-head turbines, requires that the rubber shall be vulcanized directly into the metal rings. When the rubber becomes worn, however, it is unnecessary to renew the metal ring section, as it can be again used for vulcanizing a new rubber facing to restore the ring to its original condition. This results in a considerable saving in cost of the seal rings over that for the initial installation.

The highest head under which rubber seal rings are now used is 350 ft., but similar rings, in process of construction for the Oak Grove turbines, will operate under a head of 850 ft. The largest rubber seal rings thus far made are 5½ ft. in diameter, but plans are being developed for making seals of this type commercially for the very large diameter low-head turbines used extensively in the eastern part of the United States. This plan contemplates the manufacturing of the rubber seals in strips, which are then secured to their ring containers.

Thermal Protective Devices for Motors

By Gordon Fox*

There are several devices for protecting electric circuits aside from fuses, which depend on the heating action of current for their operation. One of these is the protective plug shown in Fig. 1. This plug has, within the cylindrical unit *H*, a heating coil which melts the fusible link *L* and permits a flat spring contact arm *A* to fly to the dotted position indicated, thus interrupting the motor circuit. This device is used for small motors only.

In another device an alloy wire under tension elongates sufficiently, owing to heat, to permit closure of a pilot contact. In another type the overload-relay coil is bridged around an alloy shunt. When this shunt heats sufficiently, its resistance increases to a point where most of the current passes through the relay coil, causing it to operate. A device known as a mercury overload relay is shown in Fig. 3. Current passing through a heating coil *H*, Fig. 4, surrounding a tube *T* containing mercury, causes a part of the mercury column to vaporize and thus open a pilot circuit. All these devices based on heating effect have a time-delay feature due to thermal capacity.

The time delay obtained in the operation of overload protective devices, through the use of dashpots and most thermal devices is but a few seconds. A motor can successfully withstand a moderate overload for a much longer time. It would be desirable to have a time delay of 10 to 30 minutes in many cases, which would permit the motor to develop its full possibilities when called upon. Devices of this kind are now becoming available.

An oil-immersed thermal relay, which affords a long time delay and protects approximately in accord with motor temperature, is shown in Fig. 2. This relay contains a heat-sensitive element of thermostatic metal, immersed in oil. This element carries the current, and the oil serves to absorb the heat generated, approximating the storage of heat by the motor itself. The heat-sensitive element actuates a dial *D*, indicating the temperature condition of the relay and thus the approximate temperature of the apparatus. It also serves to open or close pilot contacts. This type of relay has thus far been applied particularly in connection with large motors and apparatus. It is probable that this general type will be more commonly applied in the near future.

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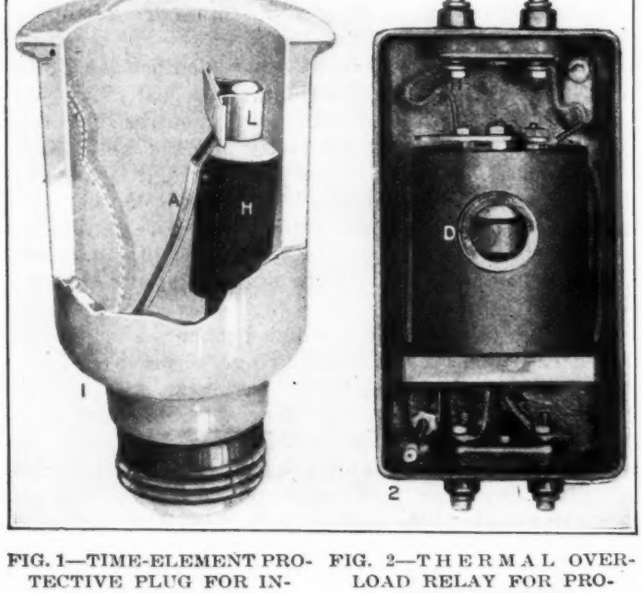
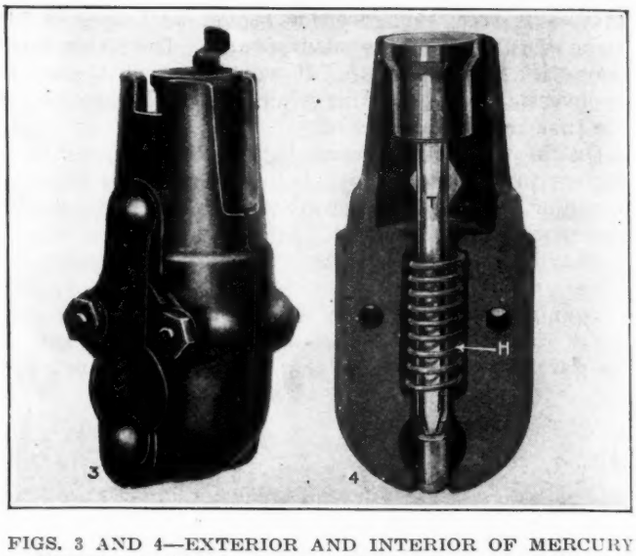


FIG. 1—TIME-ELEMENT PROTECTIVE PLUG FOR INDUCTION MOTORS

FIG. 2—THERMAL OVERLOAD RELAY FOR PROTECTING MOTORS



FIGS. 3 AND 4—EXTERIOR AND INTERIOR OF MERCURY THERMAL INVERSE-TIME-LIMIT OVERLOAD RELAY

Wear of Oil-Engine Parts

The amount of wear of all internal-combustion engines is a matter of keen interest to engineers. The statement that wear in the Diesel engine is rapid has been made so often that it is assumed by many to be true. The Diesel Engine Users' Association of England made an exhaustive investigation of the subject and found that the rate of wear was by no means uniform with different engines; in fact, extremely wide variations were met with. In all cases, however, the actual wear was far under that generally assumed.

The Busch-Sulzer Diesel Engine Co., in January, 1922, sent out blank forms to 88 firms having had type B Diesels in operation for from two to seven years. Replies were received covering a total of 58 engines. The average period of operation was 4.9 years, while ten had been in operation seven years and eighteen were only two years old.

It was found that fifty-two of the engines were overhauled not oftener than once a year, while four had been in operation over three years without the removal of heads or pistons for cleaning. The data received relating to the wear of the various parts was as follows:

Cylinder Liners: Greatest wear reported, 0.0625 in. in 3 years; 26 engines had slight wear in 4 years; 3 engines showed slight wear in 7 years; 2 engines had but slight wear in 6 years; liners renewed, 31; original liners in use, 201.

Main Bearings: Greatest wear reported, 0.01 in. in 2 years; average wear per year, 0.0016 in.

Crankpin Bearings: Greatest wear reported was 0.02 in. in 2 years; average wear per year, 0.0031 inch.

Piston-Pin Bearings: Greatest wear reported, 0.015 in. in 3½ years. On a total of 24 engines, after an average of 4.3 years' service the piston-pin bearings had never been adjusted.

Chimney Sizes

ALL chimneys of equal diameter are of the same maximum capacity, independent of the height, provided other conditions remain equal. This point is demonstrated by Alfred Cotton, who presented this paper at the spring meeting of the Fuel Division of the American Society of Mechanical Engineers, at Montreal, Canada, on May 28 to 31, 1923. Static draft of a chimney is defined as the difference between the weight of the hot gases in the chimney, provided they were regarded as stationary, and that of a column of air of the same height under conditions obtaining in the surrounding atmosphere. Chimney friction varies as the square of the velocity of the gases. If the amount of gases escaping up the chimney is increased sufficiently, a point will be reached where the chimney section equals the static draft. Draft loss in a chimney section is proportional to the height of the chimney; so is the static draft. Doubling the height of the chimney, therefore, doubles both the static draft and the draft loss, and the actual maximum capacity remains unaltered.

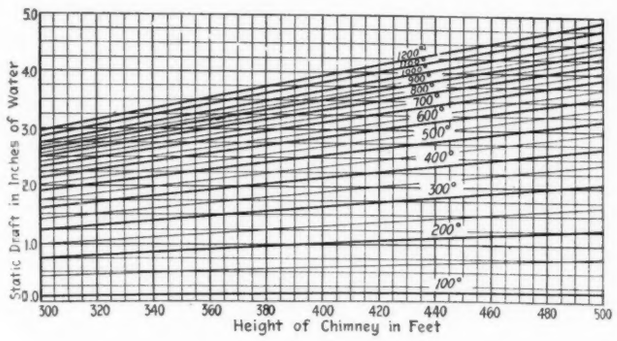
The author has placed numerous figures in this treatise, illustrating his points satisfactorily. Chimney design is treated in a brief and approximate manner, as well as with the refinements which must be taken into consideration for precise conclusions.

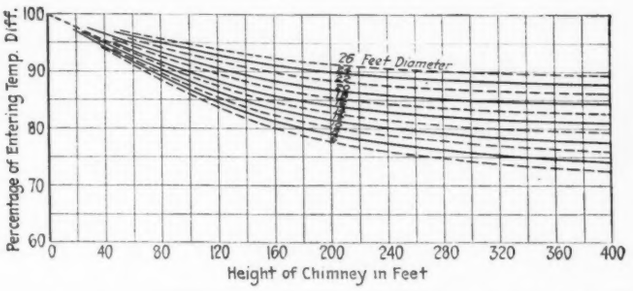
Problem—A chimney is required for three 3,000-sq.ft. boilers to be operated at normal rating, burning Eastern mine-run bituminous coal, hand-fired with natural draft. A draft loss of 0.2 in. of water through the boiler and exit gases at 470 deg. F. are predicted. Grate area, 65 sq.ft. Find the stack height and diameter at sea level.

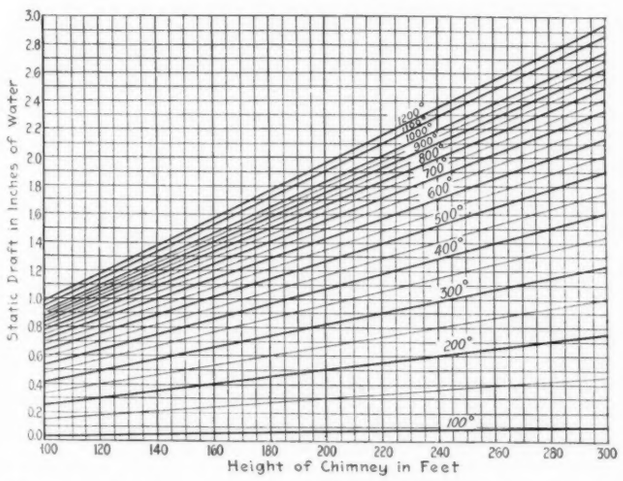
The coal has a heat value of 15,600 B.t.u. per pound of combustible. Allowing an efficiency of boiler and furnace of 65 per cent, there will be ($15{,}600 \times 0.65 =$) 10,150 B.t.u. used to make steam for each pound of combustible. Dividing the B.t.u. equivalent to one boiler horsepower rating (33,479), that is, the work per 10 sq.ft. of heating surface, by 10,150, it is found that 3.3 lb. of combustible are burned per ten square feet of heating surface per hour at normal rating. To generate the full capacity of 3,000 sq.ft. the combustible burned per hour is 990 lb. If the coal is 90 per cent combustible, the quantity burned per hour per boiler will be $990 \div 0.9$, or 1,100 lb. As the grate has an area of 65 sq.ft. the combustion rate is $1{,}100 \div 65$, or 17 lb. per square foot. Referring to Fig. 4, it is found that a pressure difference of 0.18 in. is required to burn the coal at this rate. This will be the vacuum over the fire.

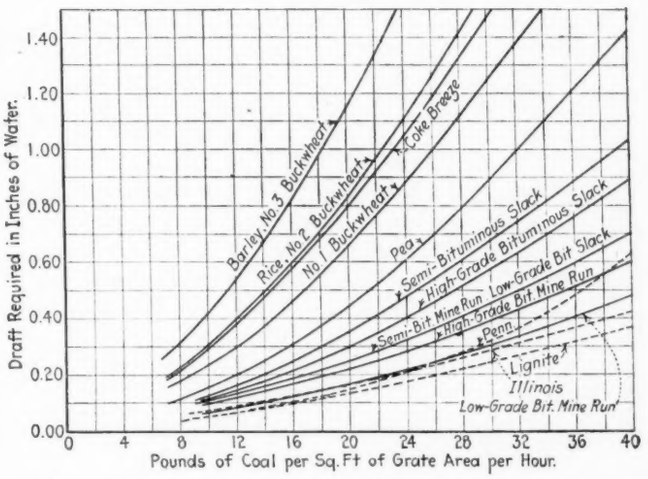
The draft loss through the boiler is given by the boiler manufacturer as 0.2 in. of water. No allowance will be made for draft loss through the damper.

The size of the flue will be based on a draft loss of 0.1 in. of water per 100 ft. Assuming that the boiler settings are 13 ft. wide, set singly with 3-ft. spaces between, the boilers will be 16 ft. from center to center, and the flue will be about 48 ft. long. By considering the amounts of gas required for each flue, the areas are









FIGS. 1 (ABOVE) AND 2 (BELOW)—STATIC DRAFT OF CHIMNEYS WITH GAS TEMPERATURES FROM 100 TO 1,200 DEG. F., AT SEA LEVEL, WITH 60 DEG. OUTSIDE AIR

FIG. 3 (ABOVE)—RELATION OF PERCENTAGE OF TEMPERATURE DIFFERENCE OF THE ENTERING CHIMNEY GASES TO HEIGHT. FIG. 4 (BELOW)—DRAFT LOSS THROUGH THE FUEL BED

worked out, and assuming one right-angled turn in to the chimney, the draft loss total for flues and turn is estimated at 0.1 of an inch of water.

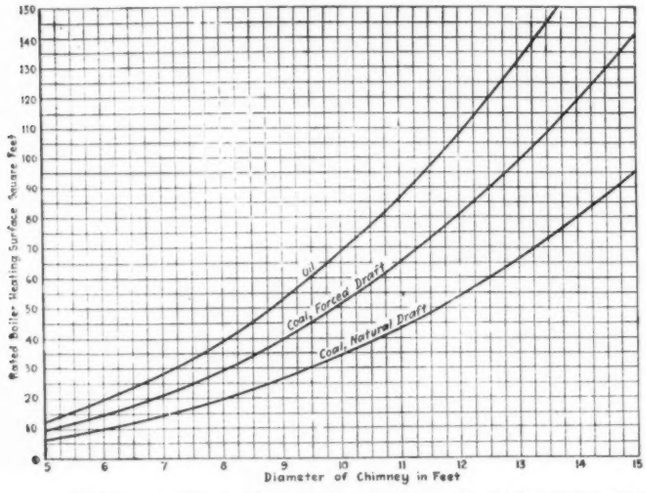
The draft required can now be tabulated as:

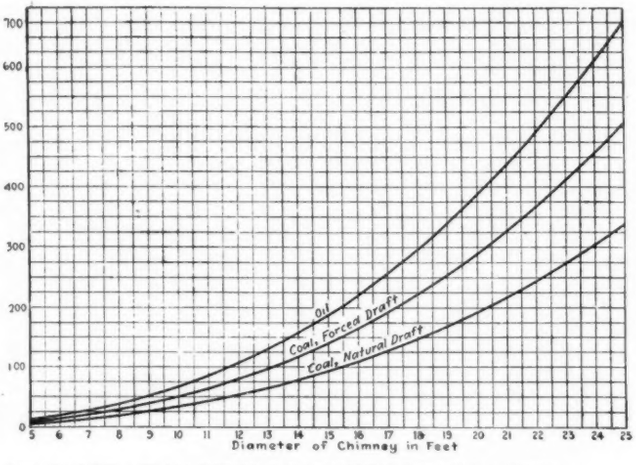
	Inches of Water
Vacuum over fire	0.18
Draft loss through boiler	0.20
Draft loss through flues	0.10
Total	0.48

The diameter is first found from Fig. 7 as 5.85 ft. Then from Fig. 6 the gas acceleration loss for maximum capacity at this diameter is read for 400 deg. F. as 0.47 in. For working conditions one-tenth of this is taken, or 0.05 in. The required draft of 0.48 in. is divided by 0.9, giving 0.53 in., to which is added 0.05 for gas acceleration, making a total static draft of 0.58 in. Referring to Fig. 2 a height of 110 ft. is found for 400 deg. F.

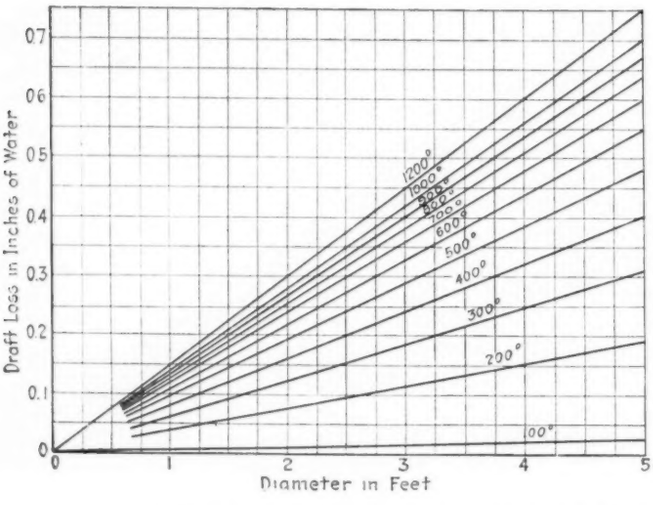
The assumption of mean temperature of gases in the chimney should always be confirmed. In this case the entering temperature is 470 deg., and deducting 60 deg. for temperature of atmosphere the entering temperature difference is 410 deg. F. From Fig. 3 a factor of 0.85 is read for a chimney 110 ft. by 6 ft. Multiplying 410 by 0.85 gives 348 deg. as the mean temperature difference, and adding back the 60 deg. gives 408 deg. F. as the mean temperature in the chimney. For approximate work no further correction is necessary for this small change in temperature. The chimney design for elevations other than sea level may be obtained from these results by means of curves also given. The author illustrates making such corrections, as well as those for variation of temperature, etc.

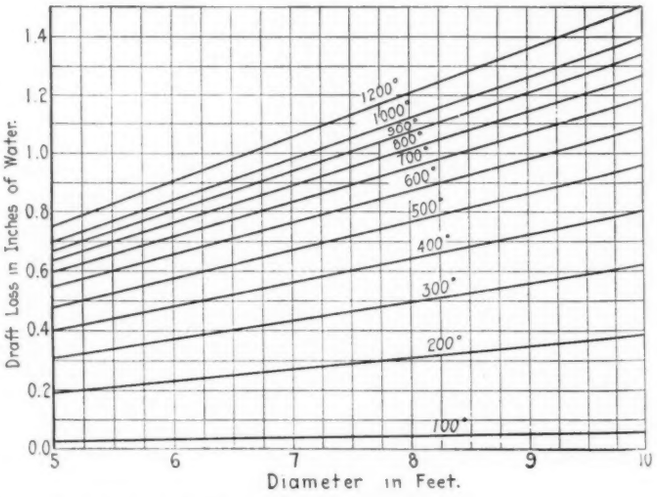
The study of chimney conditions is taken up with numerous curves and tabulations illustrating, in detail, methods employed in determining commercial designs and making choice of forced and induced draft, etc. It is clearly brought out that only by making a large number of calculations can the best choice of an individual chimney design be made. Examples are worked out in an approximate manner, and also for corrections in regard to altitude, temperature conditions, the employment of various fuels, etc. This represents an unusually clear treatment of this subject.





FIGS. 5 AND 6—DRAFT LOSS DUE TO ACCELERATION OF GASES AT MAXIMUM CAPACITY AT SEA LEVEL





FIGS. 6 AND 7—WORKING CAPACITY OF CHIMNEYS WITH 60 DEG. F. AIR AT SEA LEVEL

Curves are at normal rating; for other ratings, multiply per cent rating, in decimals, by heating surface and use this value for location on the vertical scales. Total connected heating surface based on ten square feet per boiler horsepower.

When iron or steel is heated up, a point is found where a magnet will not be able to produce attraction. This point is in the neighborhood of 1,000 deg. F.

EDITORIALS

F. R. LOW, EDITOR

Divide the Credit

AT NO previous convention of the National Electric Light Association have the technical sessions reflected such advances in power-station practice as the one just held in New York. Coincident with the unparalleled construction program of the utilities the engineers have set about to secure still greater economies in generation with the ultimate goal, as one prominent man has put it, of producing a kilowatt-hour on a pound of coal.

Recognizing that the limit had about been reached with existing methods and cycles, they have boldly jumped the pressures, employed reheating, changed the whole scheme of heat balance and adopted the regenerative cycle, besides going to powdered fuel and other refinements in many instances—not one at a time, but all together.

These innovations introduce problems in design and operation that are now occupying the best engineering thought of the country, among both the consulting engineers and the manufacturers. To predict that difficulties will not be encountered would be futile, but that they will be overcome is equally certain.

While crediting the consulting engineers and the engineering departments of the utility companies for their initiative, one must not lose sight of the hearty support being accorded them by the company executives. Without this backing and willingness to subordinate expense to achievement, little progress could be made in spite of the best engineering talent.

The Engineer Must "Sell" His Ideas

"THE proper way in which to exercise authority is to inform and convince people of what ought to be done, because if they are informed and convinced, they will do it without any compulsion. Now, informing and convincing people is an art in itself, and one in which the engineer, on an average, exhibits very little skill. If the engineer, therefore, entertains the idea that he can secure the attention of the world, and inform and convince people, without making a careful and well-directed effort to do so, he is very much mistaken. Until he learns both to talk and to write so that what he has to say is not only easy to understand, but also sufficiently interesting to capture the attention of those to whom it is addressed, he will never be in a position to exercise the authority to which his ability and importance entitle him."

These words of straightforward criticism come, not from some layman annoyed because he cannot always understand what engineers are talking about, but from a man who is himself a prominent engineer. The quotation is taken from a speech which Dr. Thomas T. Read, Supervising Mining Engineer of the United States Bureau of Mines, delivered before the American Association of Engineers at its recent annual convention.

These facts must be faced. Engineering questions of importance are sometimes decided without even getting the opinion of technical men. In many other cases expert opinion is received and then disregarded. If engineers desire more influence and standing in the community, they must add to their mastery of mechanical power a mastery of the more subtle forms of power—power of will, power of emotion, power of instinct, power of humor, etc. Without this mastery over human nature the best mechanical schemes must often fail. A passive attitude of the "truth is here if you will come and get it" variety doesn't go very far these days. If a man has an idea that he knows to be correct, he must be prepared to get out and "scrap" for it in a friendly way. The engineer must learn to apply to public affairs the same criterion that he applies to a machine—"does it work?" However perfect the design, a machine that does not operate is useless. In the same way an engineer's recommendations, be they ever so wise, are worth exactly nothing if they are not accepted.

Protection of Steam Machinery Versus Electrical

IN THE last few years engineers have become more widely interested in the value of meters and control devices, and the advantage of recording the complicated and sensitive functions of a boiler room in analytical detail has been realized. In some instances boiler conditions are handled from a central control station and the execution of mechanical operations is no longer left to the helper. A highly trained man now may press the button himself to make the required adjustment for efficient operation. Also, it is not as easy, in case of trouble, to place the blame on the helper.

In the turbine room the operator still functions to a greater extent as a free agent. Automatic control has made relatively little headway. The question of protection is gaining importance with the imminence of increased pressures and temperatures.

The condenser necessarily contains an atmospheric relief valve. Loss of vacuum is not a common cause of turbine or other wrecks. Also an overspeed device is provided. This, however, is liable to be put out of commission by many conditions, such as damage to emergency valve or tripping mechanism. The generator overload trip, where used, is by nature far more positive and dependable. Nothing, generally speaking, protects the prime mover against excess superheat or pressure outside of the boiler control. Experience to date indicates this is sometimes erratic. Bearings may fail from a number of causes. Alarms for high temperature are frequently provided, but scarcely ever for oil level, cooling water, or an excess of water accidentally reaching the oil reservoir.

Electrical protection is an interlocked system. Situations provided against in advance are handled with a rapidity and positiveness not possible through human agencies. When one safety device fails, another may

often cover the deficiency itself by functioning in a suitable manner. It is a real power for safety.

Since the maintenance involved is the bugaboo of the operating man, protective devices tend to be as simple as possible and few in number. He fears the complication and often danger that may result from inexperienced designers and may resent the introduction of such apparatus. His stand has some justification.

Nevertheless, the careful, conservative engineer must step in and improve matters. The saving from destruction of a half-million-dollar machine would more than compensate for much expensive protective engineering.

Planning for the Future

FROM the very beginning of industry down to the present time the destructive periods of inflation and deflation in business have been accepted as inevitable and no serious attention has been given to the matter until recently. Herbert Hoover, Secretary of Commerce, has attacked the problem and succeeded in interesting different industrial groups in the matter of flattening out the cycles of abnormal prosperity and business depression. Every intelligent business man must realize that what used to be called a period of prosperity was but the forerunner of a time when both labor and capital would be subjected to unwholesome stagnation.

By proper precautionary measures medical science has succeeded in preventing the ravages of disease and plagues. Engineering has to a large extent devised ways and means of eliminating the devastating effects of floods and fires. Periods of plagues and famine no longer exist in civilized countries except as they apply to industry in the form of peaks and depressions of the business cycles, which attack labor and capital alike. It is these conditions that Mr. Hoover's business barometer is intended to prevent, and this is one of the outstanding undertakings of a permanent character of his administration. The American Construction Council for stabilization of the nation's building industry has the support of the Secretary and his department in the work it has undertaken.

Although the building industry is at this time attracting more attention than any other, practically every other business feels the effects of the depression of 1920 and 1921. Three years ago, when the inflation period began, many of the power companies believed that their plant and transmission systems were overdeveloped. As a result construction programs were retarded; even if it had been desired to go ahead with the work, the difficulties of financing the projects were such as to prevent any extensive scheme of development. Today industrial progress is being retarded on account of a power shortage. Furthermore, the power-machinery manufacturers have not the facilities for taking care of the demands. This condition has come about after two years of idle factories and unemployment. Looking back over the last three or four years, it is easy to see that the power-development program of the country should have been continued through the idle years, when the construction could have been easily taken care of.

The growth in power requirements is influenced by many factors; not only must the normal increase due to industrial expansion be considered, but such elements as new applications. The electric furnace is an example of this; within the last five or six years it has come to be an important factor in the power load in different parts of the country. The coal shortage has greatly accelerated the growth of central-station loads. Many industrial plants have gone over to purchased power not so much from the question of cost as to be relieved from the difficulties and worry of obtaining sufficient coal to keep their plants running. Such influences as these and many others must be taken into consideration when projecting the demand curve into the future.

More Data Needed Regarding Chimney Phenomena

IT IS not difficult to purchase a chimney for the average plant with reasonable assurance that it can be relied upon to perform satisfactorily, as reputable manufacturers have carefully compiled data and reference tables to meet a variety of conditions. Makers of forced-draft and similar equipment must of necessity meet a like demand for determining chimney dimensions.

The engineer, however, is sometimes required to use more definite methods than empirical formulas or comparative tabulations of existing installations. It is frequently desirable to design a stack by using clear reasoning processes, fundamental laws and established physical constants. Capitalization, operation, continuity of service and other factors demand an accurate solution worked out in accordance with accepted standards.

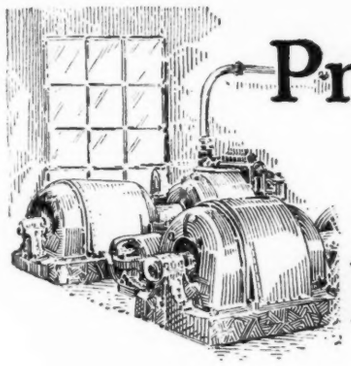
Chimney phenomena which are essentially simple, inasmuch as they deal with the ascent of a heated body of gas in a surrounding vessel, nevertheless in application depend on numerous variable quantities. Like many other subjects, attempts to lay bare the inner workings reveal how vast a territory remains to be investigated.

As pointed out by Julian C. Smallwood, in a written discussion of Alfred Cotton's paper on "Chimney Design," an abstract of which appears in this issue, the subjects of friction and mean gas temperature are far from a condition of general acceptance in the engineering world. In fact, he recommends that power plants throughout the country conduct experiments to determine friction losses and the laws governing them; the exact relation between gas temperature and stack height, air infiltration, down-drafts, local acceleration, etc. The situation regarding exactitude of chimney design might be considered as badly behind present-day engineering requirements.

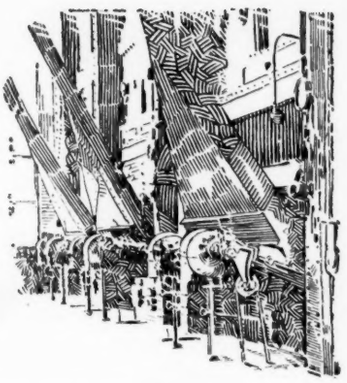
Stack friction is one of the main factors, yet a recent treatise assumes a law of friction based on that of the hydraulic equation, while there is no generally accepted experimental proof in regard to large gas volumes where eddy currents may cause appreciable complications. Mr. Smallwood further points out that the coefficient of friction lacks adequate confirmation. Two widely quoted investigators of this matter disagree by a large margin.

The mean temperature of the stack interior has been recently studied in two notable instances. Instead of really settling matters, however, the variable character of this factor has, instead, been more strongly revealed, so as to stress the necessity for general investigation. As one of the principal quantities which determine chimney capacity, this should be susceptible of precise calculation.

Many theoretical analyses dealing with chimney design are available. These methods now await experimental study of actual conditions, laws and constants as found in the chimneys of today. The results will not only add to the exactitude of calculations, but may change appreciably basic laws as now assumed and applied.



Practical Ideas *from* Practical Men



Care and Adjustment of Centrifugal Pump Stuffing Box Glands

I should like to offer a few suggestions in regard to a detail in power-plant operation that is frequently neglected; namely, the stuffing boxes of the centrifugal pumps.

In the first place most stuffing-box glands are drawn too tightly, which is done to prevent dripping water. However, all centrifugal pumps of standard design have a pocket provided to catch this water, and in the bottom of this pocket there is usually a hole which is tapped for a drain pipe. This should be connected when the pump is installed so as to keep the floor surrounding the pump dry. Nothing encourages neglect more than to have a machine surrounded by a wet or dirty floor. If these drains are properly connected, the stuffing-box glands should be backed off until a constant dripping of water comes from them. This water cools and lubricates the shaft sleeves, resulting in a saving of power and greatly increasing the life of the sleeves.

When a stuffing-box gland is being adjusted, the adjusting nuts should have an equal pull so that the gland does not bind on the shaft. Some pumps are designed so that this binding is impossible, but in most cases it is necessary to guard against it. A gland adjusted unevenly will not only bear against the revolving shaft sleeve and cause rapid wear, but will also cause heating, which in some cases will dry out the packing.

The importance of caring for the stuffing boxes in order to protect the shaft sleeve from wear cannot be over-emphasized. This consists in maintaining the proper adjustment of the glands mainly, but this is not all. A hard or gritty packing will also cause a great deal of damage. In general, the best packing is a soft graphited one. The tallow-soaked packings are also good for cold-water service only. Never use a hard stitched duck or rubber impregnated packing such as that made for packing pistons. These are abrasive and will grind the sleeves away very fast. The packing should not be wound around the shaft, but should be cut in rings. Be sure to replace the lantern so that it will connect properly with the supply pipe.

Another factor that causes wear is the grit that is contained in some water. The best way to avoid trouble from this source is to connect the stuffing-box water-sealing pipes with a fresh water supply, instead of connecting them into the pump's discharge chamber as the pump is usually supplied by the manufacturer. Where clear water is not available, the connecting pipe can be provided with a settling chamber, which will be better than supplying gritty water to the stuffing boxes direct. This grit not only cuts the shaft sleeves, but it hardens the packing, causing undue friction.

After a pump has been repacked it should be watched for a few days, as the packing will swell and cause binding. The adjusting nuts should be especially loose at first to avoid this. Also in cutting rings of packing, the rings should be about $\frac{1}{4}$ in. short to allow for swelling.

RUSSELL K. ANNIS.

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Common Sense in Power Plants

When one considers the unnecessary loss of time and the delay caused in the daily routine of power-plant work by operators and engineers failing to do the right thing at the right time, one cannot but stop to compare the operation of such plants with that of those in which the operating personnel is thoroughly trained and familiar with the work.

The engineer who has the least trouble with his plant is the one who thoroughly understands the construction and operation of the various pieces of machinery and then lays out a plan of action against any breakdowns that are liable to occur. He is never caught unprepared, and should anything happen he would know exactly what to do—where to look for the cause of the trouble, what tools to use, etc.—and would have the trouble eliminated in the minimum amount of time.

On the other hand, there are engineers who trust to luck and hope that nothing will happen. When breakdowns occur, they are at a loss as to which is the easiest and quickest way to remedy the trouble and get the plant working again. In many cases a delay of several days may be caused by some trouble which the well-trained engineer would have located and remedied in a comparatively short time.

The following instances, which actually occurred, may serve to illustrate the foregoing statements:

In a small steam plant the equipment consisted of two hand-fired water-tube boilers, a few pumps and two air compressors. The load was comparatively light, and only one boiler was kept in service at a time, the plant being shut down at night.

During one of his daily trips of inspection in the boiler room, the engineer looked through the side dusting doors in the setting and noticed what appeared to be a large blister forming on a tube in the middle nest of tubes. He decided to wait a few days before cutting the boiler out of service and removing the tube; but the following day the "blister" looked larger and it was decided to cut this boiler out and put the other one in service. This being done, the engineer proceeded to look for a spare tube, but as none was on hand, he

ordered five new tubes from the manufacturer. These arrived about one month after the "blister" developed.

When the day arrived for the removal of the tube, a fireman inserted an iron bar through a dusting door to batter down the "blister" in order to pull the tube through the tube hole. Great was his surprise when the "blister" fell off and was found to be simply a cake of soot on the tube. If the iron bar had been applied to the "blister" upon the discovery, the boiler could have been kept in use instead of being out of service for a month.

A somewhat different incident occurred in a small plant consisting of a direct-current generator direct-connected to a gasoline engine. Upon starting the set, the generator failed to build up, and the operator immediately concluded that generator had lost its residual magnetism.

He proceeded to rig up a means of providing separate excitation by connecting the ignition battery, used only for starting the engine, across the shunt-field terminals. As this failed to help any, he disconnected all the field leads, connecting the battery across various terminals, without obtaining any results. When the engineer in charge arrived to find out what the trouble was, he had all the field connections made properly again and then proceeded to trace out the shunt-field circuit to see if there were any open or loose connections. He found that the nut holding the contact arm of the rheostat in place had become loose, allowing the arm to slide back out of contact with the segments of the rheostat. The trouble was corrected at once and the machine put into service again. PETER G. DAHL.

Chicago, Ill.

Daily Test of Feed Water Essential When Treatment Is Used

So much has been written concerning boiler compounds, feed-water treatment, etc., that some engineers seem to take it for granted that compound is as necessary to a boiler as oil is to an engine. While there are many plants in which this is true, still an engineer, upon taking charge of a new plant, should take nothing for granted, but should go into the subject of boiler-feed water treatment in a thorough manner. First, determine whether compound or treatment is necessary, then whether the present treatment is proving satisfactory; if not, find out why and if necessary change the treatment. However, it should be kept in mind that many compounds and treating systems have been condemned as being of no value when in reality it was the application and not the compound at fault. To illustrate:

In a certain plant a new brand of compound was being tried. It was recommended that it should not be passed through the economizer, but should be pumped directly into the boilers. A tee was placed in the feed connection to each of the boilers, with a valve and union arranged so that an old hand pump, similar to a force-feed lubricator, could be used for pumping the compound. One of the firemen was given the task of pumping the required amount of compound into each boiler every day, but when the boilers were opened for cleaning they were found very dirty, and naturally the compound was condemned. Some time afterward one of the shift engineers noticed a peculiar deposit on the brickwork under the old compound feed connection. Examination of the other boilers showed similar deposits. It was found that the compound pump was defective, as it leaked badly in several places. The tops of the boilers were dark and hot; the fireman had been told to pump so much compound, and as he did not have to clean the boilers or pay for the fuel, he was not much interested in where the compound went after it left the pump, with the result that probably not over one-third of it got inside the boiler. If it had been the custom in this plant to make daily test of the boiler water, the trouble would soon have been detected and the compound, likely, would have proved satisfactory.

One fact concerning the use of any compound (which also applies to many of the other methods of treatment) is that no truly satisfactory results can be secured unless daily boiler-water tests are made. The necessary equipment and chemicals for performing these tests are inexpensive; in fact, some of the boiler-compound companies furnish them with their compound. The process is simple, and any person capable of operating a boiler should have no trouble in obtaining accurate results if directions are carried out.

Occasionally, a plant is found where feed-water treatment is unnecessary and money spent for compound in such a plant is thrown away. When taking charge of my present plant, I inquired of the operating force concerning the feed water, scale, etc., and was informed that a good boiler compound was being used. They were sure it was good because there was never any scale in the boilers. I examined the boiler that was not in use and found no scale and no sign of corrosion. Next, I opened the open feed-water heater and found that it was choked with scale—the accumulation of over two years I was told. The use of compound was at once discontinued, and after a week I opened one of the boilers. In each of the four drums I found a hatful of soft pink sludge, which upon drying, formed a soft, fine-grained powder, similar to ordinary talcum—probably magnesia. Otherwise the boiler was clean. As a large percentage of the condensate is returned to the feed-water heater, the amount of raw makeup water is small and most of the impurities carried in it are precipitated in the heater at a temperature less than 212 deg. The remaining impurities are of such a nature that, by a judicial use of the blowoff, they are either removed or remain in solution. The use of compound was then discontinued, with the result that in the five years that have passed every inspection has found the boilers free from scale and corrosion. There has never been a tube cleaner or scraper used in the boilers, nor have we ever lost a tube, and only two tubes ever required rerolling; this in spite of fact that the boilers are forced to carry considerable overload at times. Of course this happy state of affairs is not found often, but has been mentioned to illustrate the point that engineers should not become dogmatic in the use of compound, for there are cases where it is not needed. A. C. MCHUGH.

Norwalk, Calif.

Although it is not generally recognized, nevertheless that part of practical steam engineering that comes under the head of steam traps, their selection and application, is as important as any other phase of the profession. While an engineer may select his turbine on a guarantee of one-half of one per cent better efficiency, he may be losing two or three per cent through faulty traps or the lack of traps. He may be using the utmost care in his engine and boiler room, but more than waste all this effort through leaky drips or through poor results in process or other production work.

Comments from Readers

Trouble from Straight-Tube Heater

With reference to the answer given to the inquiry on "Trouble From Straight-Tube Heater," in the May 8 issue, it seems to me that the straight-tube heater received much undue criticism.

Straight-tube closed-type heaters do give highly satisfactory service provided the design and construction are right. Expansion or contraction of any material occurs with a change in temperature, and this fact, if not recognized and considered, will unquestionably cause trouble.

The coefficient of expansion varies with different materials, and also the temperature in different parts of a heater may vary.

The straight smooth tube has been used for years in closed-type heaters with best results when the expansion and contraction are taken care of by a floating tube head at one end. Dependent upon the service of the heater, the different tubes, particularly those of one pass as compared with those of another, may differ somewhat in temperature, but this slight difference is absorbed or compensated for by the flexibility of the tubes themselves.

Leakage between the tubes and the tube sheets would occur in any construction, whether straight tube, spiral or other form, provided the workmanship and principal used in fixing the tubes into the tube sheets were not suited to the purpose.

Proof that straight-tube floating-head design of heaters is satisfactory and reliable, is that most heaters of large size, say 500 sq.ft. and larger, are of this construction.

The application of closed heaters in obtaining the station heat balance in steam-power generation in connection with stage bleeding has become popular and is used almost exclusively today. In this service the majority of the heaters sold have been of the straight-tube floating-head type.

C. M. HARDIN.

New York City.

Bearings, Bearing Metals and Lubrication

I was much interested in the article on "Bearings and Bearing Metals," by A. B. Trix, in the Feb. 20 issue, and he has opened a subject on which I should like to present some of my experience. In the first place, it may be said that the subject of frictional wear and the suitability of various alloys to withstand frictional loads in a satisfactory manner is one of the most complex mechanical and metallurgical problems. Frictional losses, and therefore wearing of bearings, are dependent on many factors—not only pressure and the constitution of the bearing metal, but also the speed of revolution, lubrication, etc. In a good engine working at full load the friction of the main bearings may amount to from 6 to 8 per cent of the power expended, while at quarter load from 30 to 40 per cent may be used up. It is, therefore, evident that there is decided room for progress in the reduction of avoidable frictional losses.

One of the functions of a lubricant is to overcome or neutralize accidental variations of the smoothness of surfaces. A light oil lubricates as well as a viscous one when all is smooth; but when a minute irregularity occurs, such as grit or rough places on the surfaces, heat is generated locally, the oil becomes too thin, and there is a risk of seizure taking place. By the use of a plentiful supply of viscous lubrication this risk can be considerably reduced. A new engine underlubricated will seize much more readily than one well run in.

There are other conditions to meet where a viscous lubricant is necessary, such as great pressure, slow speed and high temperature. The following table shows roughly the change of viscosity with rise of temperature:

Temperature, deg. F.	75	110	150	250	300	350	400
Time of efflux,* sec.	740	110	54	39	32	25	21

*"Time of efflux" means the time taken by a given volume of liquid to flow through the orifice of the instrument used in measuring the viscosity.

It appears that for many purposes the structure of a bearing metal should consist of two constituents of different hardness—the one plastic, which permits the rotary section to obtain a perfect fit or "seating" either by rapid wear of isolated sections or by general distortion or "flowing" of the plastic mass; the other hard, the object of which is to give a low coefficient of friction and to resist wear. Obviously, the proportions of these two constituents will vary for different purposes.

If a bearing metal has to withstand heavy loads, it will contain a relatively large proportion of the hard constituent. If the bearing pressure is low, it will contain less of this constituent. The proportions of the two constituents are dependent on the chemical composition and also on the rate of cooling; the slower the rate of cooling the more the crystals develop, and other conditions being constant, they are less evenly distributed throughout the mass. The rate of cooling has an enormous effect upon the crystallization and structure of the metals, and this point should be realized by the users of bearing metals.

Experience has shown that a perfectly good metal can be made practically worthless for bearings by allowing it to become too hot, also by pouring when too hot or too cold, yet sufficient attention is not given to this, the matter being frequently left to the ordinary workman, who is never a skilled metallurgist. In modern practice, to maintain temperatures at the proper values a thermocouple is connected to an indicating millivoltmeter, calibrated in degrees Centigrade or Fahrenheit, which is inserted in an iron tube which is placed in the molten metal. A further development of this scheme involves the use of an automatic attachment which controls the temperature by regulating the flow of the gas. This arrangement is reliable, and once adjusted, it requires no further attention as it works automatically.

The opinion still prevails among some engineers who make their own bearing metals that the quality is influenced by the order in which the various metals are melted and combined. This, however, has been disproved by experiment the results of which indicate that as regards bearing metals, foundry secrets or mysteries of mining have only a fancy value, and that although some particular methods may have value as to convenience or even as to accuracy of the final product, they are not essential as regards the quality of the bearing metal.

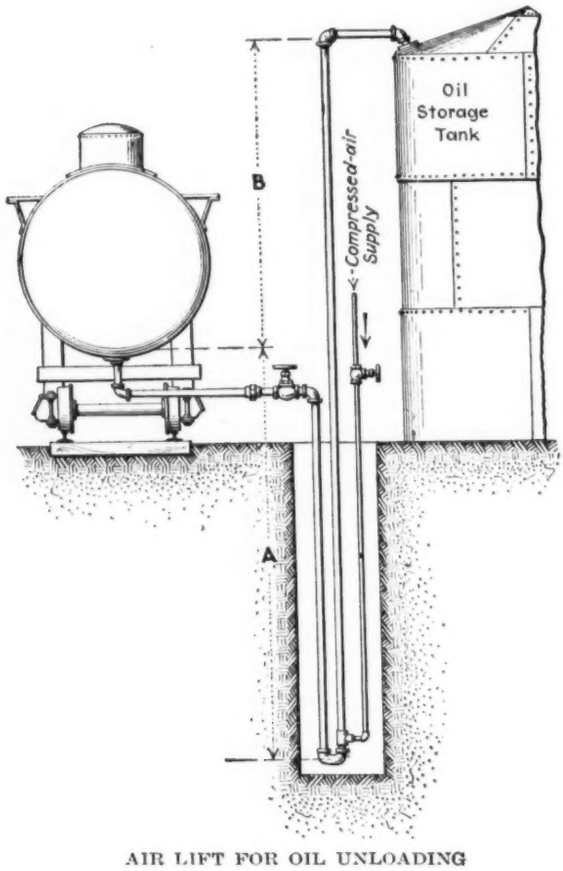
In conclusion, it may be safely said that many of the difficulties with bearings were more or less attributable to design. A fact sometimes overlooked was that a main crankshaft bearing designed for an engine working at 60 lb. per sq.in. initial pressure was no longer suitable if the pressure of the engine was increased to 100 lb. per sq.in. This fact was sometimes overlooked, but it was at the root of many bearing troubles.

Manchester, England. E. ANDREWS.

Unloading Tank Cars by Compressed Air

In *Power*, March 27, Colin K. Lee described a method of unloading oil from tank cars by draining into a steel barrel, closing the valve and blowing from the barrel into the storage tank by compressed air.

It is well to note that most oil barrels are not made



AIR LIFT FOR OIL UNLOADING

strong enough to stand any great pressure, and that the failure to open the discharge valve before air is admitted may result in bursting the barrel. The method described also requires much attention.

The writer suggests the following way for use where the oil is not extremely viscous. The piping is arranged as shown in the illustration, with an oil pipe leading from the tank car, down into a pit to a depth such that the drop *A*, below the lowest level of oil in the tank car is at least as great as, and preferably 1½ times as great as the lift *B* from the bottom of the tank car to the discharged pipe which enters the storage tank. Near the bottom of the rising pipe compressed air is introduced through a tee, as shown.

The action is that of the air lift, which has been thoroughly discussed in recent articles appearing in *Power*. The opening of the valve in the oil pipe permits the oil to flow down the pipe, through the return bend and into the rising pipe to the level of oil in the tank car. When the compressed-air valve is opened gradually, the bubbles in the rising oil pipe lighten that column of liquid, so that the oil level rises higher and higher and finally reaching the top of the rising pipe, overflows into the storage tank.

Once started, the flow continues as long as the compressed air is supplied or until the tank car is empty. Although the viscosity of the oil retards its flow, it also retards the motion of the air bubbles through the oil, thus increasing the effect of the bubbles in decreasing the weight of the higher column of liquid. For this reason viscosity of the oil does not interfere with the action of the air lift as much as might at first be expected.

The main precaution in using this device is to avoid opening the air valve too quickly, as that would result in blowing oil both upward into the storage tank and back into the tank car. The tee by which air is admitted to the oil pipe must be located on the riser so that the bubbles will rise in that direction, and not into the tank car. The oil storage tank must, of course, be vented to avoid a pressure in it.

The oil entering the storage tank is full of air bubbles, which quickly rise to the surface and break. One advantage of this method is that it operates with very little manipulation; once started, it is not necessary to change any valves until the car is empty. It is believed that the quantity of air required by this method will generally be less than for direct blowing, though this will depend much on the depth of the drop pipe in the pit. T. M. GUNN.

Brooklyn, N. Y.

Stationary-Tube Centrifugal Boilers

I read with much interest the article in the Feb. 13 issue describing the Atmos boiler, designed by Mr. Blomquist, of Sweden. The conventional water-tube boiler suffers from a basic defect which becomes increasingly important as the pressure and temperature rise. This is the use for steam generation of a long tube completely filled with water. A bubble of steam generated at the water end of the tube has to travel the entire length of the tube before it can reach the steam outlet. To facilitate this travel, the boiler tubes are made inclined, and in some types even vertical, but this helps only partly.

The undesirable results created by this steam travel may be grouped under the following heads: In the first place, there is a tendency for the steam to accumulate in excessive amounts in the part of the tube near the steam end, which has to convey the entire steam generated in the tube. As the steam naturally tends to accumulate in the upper part of the tube, this may lead to part of the tube near the steam end being filled with

steam only, and this in its turn, because of the low heat conductivity of steam, may lead to tube overheating.

In the next place, as the bubbles of steam travel through the length of the tube, they are subjected to friction against the water and jarring against other bubbles, which leads to their breaking into minute bubbles, which, with a suitable pressure and temperature (the exact magnitudes of which have not yet been determined, but which must lie above 500 deg. F. and 300 lb. pressure), may lead to a formation of an emulsion-like structure, a sort of "compressed foam," the important disadvantage of which is that it is a poor heat conductor and is therefore likely to delay the vaporization of the water and also lead to overheating and consequent weakening of the tubes.

There is, however, another important weakness of the conventional water-tube boiler which has been fully realized by designers, but no efficient means have been found to combat it under ordinary conditions, and this is the excessive area of the tube cross-section as compared with its circumference. Our problem is to convert as much water as possible into steam per unit of time per boiler tube. To do this, we have to put into the water a given, fairly large, amount of heat units, and the problem becomes more and more difficult as the pressure of the steam increases. Plenty of heat is assumed to be available on the gas side of the tube, and the problem is how to carry it away by the water in the shortest possible time. It is obvious that the thinner the layer of water adjoining the tube, the faster can steam be generated, which is the well-known secret of the comparatively high output of flash boilers, such as the Serpollet and De Laval types. This is also the reason why small tubes are used in regular water-tube boilers, wherever possible. Assume that for a high-pressure high-output boiler a layer of water one inch thick will give the fastest evaporation consistent with safety (this is approximately correct). Then in a 4-in. boiler tube we have 25 per cent of the area outside of this range of optimum efficiency. Whatever the loss caused thereby may be, it means that we are not operating at the best possible efficiency, which is wrong.

The first consistent effort to meet this condition has been made in actual practice by the Atmos boiler. In this boiler the tubes are made to rotate, which throws the water by centrifugal force outward, and leaves in the interior of the tube a free passage for the steam. Such a construction meets all the objections to the water-tube boiler of the conventional design, but unfortunately introduces some objectionable features of its own. Let us discuss the advantages first.

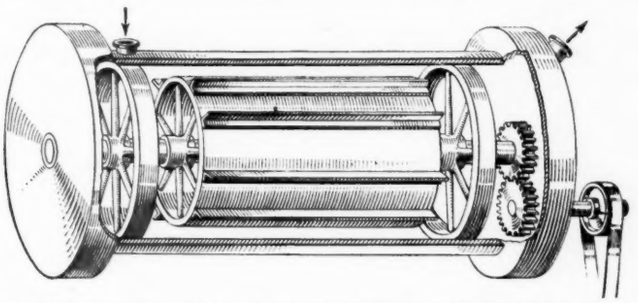
As the water is held against the wall of the tube by centrifugal force, the thickness of the water sheet may be easily regulated and may be held at the size desired for best efficiency.

Furthermore, a layer of water at all times covers the entire length of the tube and protects it from overheating. Finally, the steam as it is formed is squeezed out of the water by the centrifugal force acting on the latter and escapes into the free central passage. There is, therefore, no tendency to form the emulsion previously referred to.

The disadvantages are fairly obvious and serious. Rotating boiler tubes mean numerous joints and possibilities of leaks. These joints can be kept tight, as proved by the fact that an Atmos boiler has been actually at work for a year in a Swedish sugar refinery, but they require unremitting attention. It may be easy to look after the packing of a small boiler, but how about our big central stations? The problem of keeping tight thousands of joints would be a formidable one indeed.

It was to meet the situation set forth in the foregoing that the centrifugal water-tube boiler with stationary tubes was developed, and parenthetically it might be stated that there was no intention to give out its description until public attention had been called to centrifugal boilers generally by the publication of the description of the Atmos boiler.

In this boiler, as shown in the illustration, each tube contains a rotor with paddles extending nearly the entire length of the tube and driven from gears contained



ROTATING PADDLE IN BOILER TUBE INCREASES RATE OF EVAPORATION

in one of the headers. This construction achieves all that is claimed for the Atmos boiler, but is free from many of its disadvantages. In the first place, the general construction of the boiler follows well-established conventional lines. The tubes have to be somewhat larger (from 6-in. up), but their general design and installation are not affected except that, instead of being inclined, they are made horizonal. The rotors are simple paddles running at moderate speeds (450 r.p.m. for a 6-in. tube), and no difficult problems are involved in their construction or in their operation. The entire mechanism is inclosed in the boiler header, and there is only one small joint to be kept steamtight; that is where the driving shaft passes through the header wall, a problem which is simple of solution.

A boiler of this character is of course somewhat more expensive to build, probably about 15 per cent in excess of the conventional type, but on account of the higher evaporation, a smaller tube area is required, so that it is by no means certain that, for a given output, the centrifugal boiler will prove to be more expensive than the stationary type.

There is one point, however, in which the centrifugal boiler is inferior to the stationary type, and that is, with respect to tube cleaning by scraping, which cannot be done in the former without removing the tube paddles. This objection is not so serious as it looks at first. The main field of the centrifugal boiler is in the field of high-pressure central-station power plants, and there proper water-treatment facilities should be provided, sufficient at least to prevent heavy incrustations on the boiler-tube walls. Where the effort to improve power-plant efficiency is carried to the extent of using the high pressures and high superheats of the "power plant of to-morrow," one would certainly expect that sufficiently clean water is used for feeding the boilers to prevent the enormous heat losses due to slag-incrusted tubes.

No attempt is made to describe the auxiliaries; for example, special gages to read the water level in the tubes, etc.

LEON CAMMEN.

New York City.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Dependence on Steam for Cylinder Lubrication

Are large reciprocating steam engines ever operated without the use of oil or other lubricant for valves and cylinders? E. A. B.

In marine practice, where condensing engines are employed, it is quite general to depend on moisture of the steam for lubrication of valves and cylinders rather than incur danger of the boilers becoming burned from the presence of cylinder oil in the condensate returned to the boilers. Engines carefully designed, constructed and operated for service with only steam lubrication of the cylinders, have been used for long periods without serious injury, and often with the development of excellent rubbing surfaces for valves and pistons.

Forcing Boiler Fired with Natural Gas

Can a horizontal return-tubular boiler, fired with natural gas, be forced about 50 per cent above its rated capacity without blistering the bottom of the shell if the boiler is clean of scale? T. W. W.

It is not likely that a boiler shell made of homogeneous steel will become blistered or burned if there is no impingement of the gas flame against the outside and the inside is kept perfectly clean of scale or dirt, especially greasy deposits. From increasing the evaporative capacity 50 per cent, the same amount of deposit would be formed in two-thirds of the time, and to be assured that the shell is maintained in as clean a condition as when the boiler is operated at the normal rating, the length of time between washings should be reduced to two-thirds.

Trouble Pumping Hot Water

We have considerable trouble in operating a boiler-feed pump that takes suction from an open heater. The pump is only two feet above the heater, and the temperature of the water is about 180 deg. F. Should not the pump work properly if the packing is good? C. W.

Pumpage of hot water with a suction lift cannot be depended upon. A partial vacuum formed by displacement of the pump piston permits the first hot water entering the suction chamber to burst into vapor and, after a few strokes are made, the pump cylinder and suction chamber become steambound unless the pump is run very slowly. For certainty of operation the pump should be placed lower than the heater with a full size of suction pipe, so the suction water may be delivered under a head. Then, for moderate piston speeds there should be no trouble due to ordinary condition of the pump packing beyond a small percentage of piston slippage.

Water Pressure Against Sides of Rectangular Tank

What would be the pressure on the sides of an open rectangular tank 25 ft. long and 8 ft. wide, when the depth of water in the tank is 2 ft., and when 4 ft.? W. W. T.

In a perfect liquid like water, the pressure in every direction at any point is directly as the depth. A cubic foot of water at 62 deg. F. weighs 62.335 lb., and the pressure increases with each foot increase of the depth at the rate of 62.335 lb. per sq.ft., or $62.335 \div 144 = 0.433$ lb. per sq.in. When the depth of water is 2 ft., the pressure at the bottom is $62.335 \text{ lb.} \times 2 = 124.67$ lb. per sq.ft., and as the pressure at the surface is 0, the average pressure would be $(0 + 124.670) \div 2 = 62.335$ lb. per sq.ft. As for a tank 25 ft. long and depth of water 2 ft., the area of each 25-ft. side of the tank subjected to pressure would be $25 \times 2 = 50$ sq.ft., the total pressure exerted against each 25-ft. side would be $50 \times 62.335 = 3{,}116.75$ lb., and the total pressure on each 8-ft. side would be $8 \times 2 \times 62.335 = 997.36$ pounds.

In the same way, for 4 ft. depth of the water, the average pressure against the sides would be $62.335 \times 4 \div 2 = 124.67$ lb. per sq.ft., the area of each 25-ft. side subjected to pressure would be $25 \times 4 = 100$ sq.ft., and the total pressure of the water against each 25-ft. side would be $100 \times 124.67 = 12{,}467$ lb., the area of each 8-ft., side subjected to pressure would be $8 \times 4 = 32$ sq.ft. and the total pressure against each 8-ft. side would be $32 \times 124.67 = 3{,}989.44$ pounds.

Correcting Settlement of Boiler and Measuring Drop of Back End

In raising up the front ends of three return-tubular boilers that have settled at the front ends, what would be the procedure and what is the best method of measuring the amount of drop on the back end? W. W. S.

The first thing would be to disconnect all piping, smoke connections, boiler fronts and boiler connections, and remove any parts of the boiler setting such as brickwork of the front or rear walls or brickwork over supporting lugs or any that closed in on the shell or that would interfere with raising the boilers. Before elevating the boiler shell, establish a distinct mark of reference on a stationary object like a near-by building wall, to indicate the level of the under side of the front end and a mark on the flush front that is to correspond when repairs are completed.

If the settling is attributed to crumbling or crushing of the side walls, they should be replaced by better workmanship or reinforced to obtain greater bearing strength with good compensation for expansion and

contraction. If the settling included the foundations, new foundations and bearing walls will be required unless there are evidences that the foundations have stopped settling, and in that case, good portions of the walls can be retained and be built up to the height necessary for the proposed elevation for the boilers.

When the front is removed, block up the boiler shell about six inches higher than the final level and have blocking clear for performing any work required for building up the walls and the new bearings for the boiler lugs. If the anchor bolts for holding the front in place are left in the old walls, the fronts will need to be redrilled with holes to receive such bolts. When the boiler has been lowered to the new permanent level with the side lugs resting on the rollers and expansion plates, remove the blocking and rebuild or make necessary alterations of the back connection and also of the front wall so the opening and height of firedoor dead plates will match the openings in the boiler front when it is placed in position. Make necessary alterations of the furnace for receiving the grate bearing bars at the new level required by the dead plates, complete the front connection, close in the side walls to the sides of the boiler and repair or replace the insulation on the top of the boiler.

When a boiler is resting on the setting, the best method of measuring the drop at the rear end is to observe the depth of water at that end when the bottom of the boiler at the front end is just covered by the water; or the difference of level of the ends would be practically the same as of points on opposite ends of the outside of the shell, when both points are taken at the highest part of the top or lowest part of the bottom of the shell at or near the respective ends.

Setting D-Slide Valve Without Turning Over Engine

How can the D-slide valve of a horizontal engine be set well enough for practical work if the engine is too large to be conveniently turned over by hand?

M. A. Y.

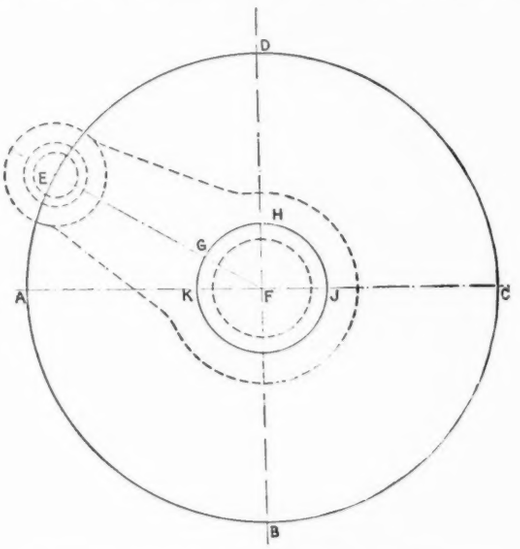
For setting a D-slide valve, the first operation is to adjust the eccentric rod or valve rod to such a length that the valve will be centrally over the ports when it is at the middle of its travel. For that purpose remove the valve chest cover, loosen the eccentric, swing it clear around the shaft and mark the valve seat at the point to which each end of the valve travels farthest beyond the outside edge of its steam port. If these overtravels are unequal, lengthen or shorten the eccentric rod or valve rod connections, as may be necessary to make them equal.

Knowing the direction of rotation of the engine and the position of the crank, swing the eccentric clear around the shaft in the direction of rotation, until the valve begins to uncover the steam port on the end of the cylinder which should take steam to obtain forward rotation of the crank, and temporarily set the eccentric enough farther forward to obtain about ¼ in. opening or the desired amount of lead. The eccentric then will be as much behind its proper angular position with respect to the crank as the angle through which the crank would have to be turned backward to the position of dead center.

Make a mark on the side of the eccentric to correspond with a mark on the shaft. If the crankpin stands vertically over or under the center line of the shaft, permanently set the eccentric to a position that is one-quarter of the circumference of the shaft in advance of the temporary setting.

If the crank has not completed 90 deg. of rotation past the dead center, to find the angle through which the eccentric should be set in advance of the temporary setting as shown in the figure, draw a circle *ABCD* with radius equal to the radius of the crank. Then with the center line *AC*, drawn to represent the center line of the engine, locate a point *E* on the crank circle to represent the position of the crankpin center above or below the center line *AC*, connect *EF*, and the angle *AFE* will be the angle through which the crank is in advance of the dead center *A*. With *F* as a center and radius equal to the radius of the shaft at the eccentric, describe the circle *GHJK* and the length of arc *GK*, transferred to the shaft alongside of the eccentric, will give the distance the eccentric is to be set around on the shaft in advance of the temporary setting.

However, if the crank has completed more than 90 deg. past the dead center, then assuming the dead center



FINDING ANGLE FOR SETTING ECCENTRIC

to be at *C*, the angle through which the eccentric would have to be moved would be *CFE*, and the distance for advancing the eccentric ahead of the temporary setting measured around on the shaft alongside of the eccentric would be the length of the arc *JHG*, which may be transferred to the shaft by spacing with a pair of dividers.

Pounding of Duplex Fire Pump

We have an 18x10-in. duplex fire pump that gives trouble by pounding from overstroking. How can this be prevented?

G. W. D.

Such pumps usually are provided with cushion valves for increasing compression, thereby obtaining a cushioning effect and with enough reduction in length of stroke to prevent pounding. The pounding may be due to suddenly arresting the water in a long suction pipe and also may be due to discharging against less pressure than intended for the design of the pump. Pounding from momentum of the suction water can be largely prevented by employing an air chamber on the suction line near the pump, with cubic capacity two to three times the displacement of one water piston.

Easy Lessons in Engineering

The Meaning of Efficiency

A great deal is heard about efficiency these days. There are few ideas more useful and few more abused. In its strictly scientific and engineering uses the word "efficiency" has one well-defined general meaning; namely, the ratio of what is taken out usefully to what is put in. More briefly, efficiency is the ratio of *output* to *input* and may be written as follows:

$$Efficiency = \frac{Output}{Input}$$

Practically all of the hundreds of different efficiencies used in engineering come down to this simple expression if the proper meanings are attached to the words "output" and "input." In the first case "input" refers to the amount of power, energy, work, etc., supplied, while "output" refers to that portion of the power, energy or work given off which is of value for the purpose under consideration. "Output" never refers to the total amount given off in all ways. This total must always be equal to the total amount supplied except where the machine can store up energy to be given off later, as in the case of a flywheel. Even here the total output of energy must equal the total input in the long run.

In order to have the efficiency mean anything definite, it is essential that the output and input be measured in the same units. If the input is measured in foot-pounds of work or energy, the output must also be measured in foot-pounds. If the input is in B.t.u., horsepower or kilowatts, the output must be in B.t.u., horsepower or kilowatts respectively. Any such efficiency—when dealing with work, energy or power—can never be greater than 1 (or 100 per cent, which is the same thing). This best possible efficiency occurs where all the energy supplied is given off in a useful form. This is the case with an electric heater, where the entire input of electrical energy is turned into heat energy. As a heater the efficiency is 100 per cent. As a work-producing machine the efficiency is zero, since no mechanical work whatsoever is produced. Electrical and friction heating devices can have an efficiency of 100 per cent, but no machine whose useful output is in any other form (such as work or electricity) can have this efficiency, because some of the energy supplied always slips away as heat.

A certain electric motor might have an efficiency of 80 per cent, meaning that 80 per cent (or 0.8) of all the electrical energy supplied is given out as mechanical work. The other 20 per cent must go somewhere and, as is the case with most machines, turns into heat. So the efficiency of this motor *as a heater* would be 20 per cent. These simple examples show the importance of seeing clearly what particular kind of output we are thinking about.

Another thing to keep in mind is the extent of the apparatus to which the particular efficiency being figured is to apply. This is best pictured by imagining a circle drawn about the single machine, group of machines or part of a machine to which the efficiency is to apply. For example, the expression "thermal efficiency of the whole plant" is pictured by drawing a circle around the entire plant and considering only the energy that passes into or out of this circle. No attention need be paid to anything that happens inside the circle.

The only energy entering the circle is that in the coal supplied, and the only useful energy leaving it is that carried by the electrical cable, shaft or belt which delivers the power. (This, of course, does not apply to any plant where steam or hot water is sent outside for heating or manufacturing purposes.) While any desired unit of energy, power or work may be used in figuring this efficiency, the most convenient is the B.t.u. It makes no difference whether the time considered be long or short, since increasing the time increases both output and input in the same proportion and therefore does not change the ratio of one to the other.

A convenient time to take is that in which the plant produces one kilowatt-hour. Suppose the plant consumes 2.3 lb. of 14,000-B.t.u. coal per kilowatt-hour. Then the total input during this period is $2.3 \times 14{,}000 = 32{,}200$ B.t.u. and the corresponding useful output 3,415 B.t.u., since one kilowatt-hour is equivalent to this quantity of heat energy. We then have

$$Efficiency = \frac{Output}{Input} = \frac{3{,}415}{32{,}200} = 0.106, \text{ or } 10.6 \textit{ per cent.}$$

Instead of a whole plant we may be dealing with a single machine or even a certain part of a single machine. A good example of the latter is found in figuring the mechanical efficiency of a steam engine. If the indicated horsepower of an engine is 126 i.hp. and the power delivered at the shaft 111 b.hp. (brake horsepower), we say that the mechanical efficiency is $\frac{111}{126} = 0.88$, or 88 per cent.

Here no attention is paid to the heat energy in the entering steam, since we are considering only the efficiency of the mechanism or moving parts of the engine. The input of the moving parts is the actual power delivered to the piston by the pressure of the steam. This is figured as 126 i.hp. from indicator cards which give the average pressure of the steam, from measurements of bore and rod diameter which give the areas for figuring the total force, and from measurements of stroke and revolutions per minute which give the total distance through which the force acts in one minute.

The output in the same units is 111 b.hp., the 15-hp. difference being due entirely to friction and therefore being properly called friction horsepower. The energy corresponding to the 15 hp. used up in friction is not destroyed, but merely turned into heat.

N. E. L. A. Discusses Power Plant Problems

THE forty-sixth annual convention of the N. E. L. A. was held last week, June 4-8, at the Hotel Commodore, New York City, with a registration of nearly 7,500. As usual, the sessions were divided into several groups comprising general and executive sessions, public policy, accounting, commercial and technical. It is the last-named group which most concerns *Power* readers. Owing to the many developments now going on in the power-plant field, embodying innovation in design and practice, the technical program this year was replete with information from the operating companies, the designing engineers and the manufacturers, and the discussion brought out clearly the problems that have arisen as a result of the effort of designing engineers to secure still greater economy in plant operation. The following sets forth some of the high spots of the various committee reports, the addresses of prominent engineers and the technical discussions.

The report of the Prime Movers Committee this year was issued in two sections. It is felt, however, that presentation of such a bulky report at the time of the annual convention does not afford opportunity for digesting and making the greatest use of the vast amount of material that it contains. Therefore, the committee has decided hereafter to issue the report in installments at fairly regular intervals throughout the year, each installment to contain reports of from two to five subcommittees.

Abstract of Prime Movers Committee Report

MUCH progress toward higher pressures and temperatures has been made during the year. A few plants have been operating with 350 lb. pressure and temperatures from 600 to 650 deg. for several years. Plants are now being constructed to operate at pressures from 400 lb. up to 550 lb. at the boiler. In one case boilers are being provided for 650 lb. pressure, but the turbines will be operated at 550 lb. The steam temperatures adopted in these plants range from 650 to 750 degrees.

Information coming to the committee indicates that many engineers feel that the adoption of pressures as high as 550 lb. at the present time represents too long a step into the unknown and that the advance to such pressures should be made slowly and conservatively. On the other hand, they agree that it would certainly be an error in judgment to adopt 200 or 250 lb. for new work without giving thorough consideration to the possibilities latent in higher pressures.

Station Piping

The great differences in the pressure drop between boilers and turbine throttles in various plants suggested the desirability of an investigation of this subject. Several member companies submitted data, and a brief study of this material is sufficient to indicate that large pressure drops are not necessary. The effect upon pressure loss of the design of piping, and particularly the design of valves and fittings, should be given serious consideration before final adoption. Instances are on record in which slight modifications in design of such parts reduced the loss through them to values between one-tenth and one-half of those previously considered normal.

The increasing use of high-temperature steam has served to focus attention on steam-pipe insulating covering. Some few of the member companies appear to have made experimental investigations of this subject. Practice differs greatly, and all the materials sold for this work seem to be in extensive use. However, 85 per cent magnesia is still the predominant material. It is generally protected against excessively high temperatures by the use of some other material between it and the pipe.

The subject of pipe bends and expansion joints is becoming of greater importance as operating temperatures and pressures rise. Expansion bends or offsets seem to be in almost universal use for high-pressure lines. These are reported as giving entire satisfaction except for leakage at flange joints in some cases.

Coal and Ash Handling

Data on methods for handling coal and ash have been compiled from 41 representative central stations. These data have not yet been studied sufficiently to make it possible to generalize, but certain facts are of interest at this time. Seasonal outdoor storage is provided at only 18 out of the 41 plants reporting, and several mine mouth plants are included in the 18. Locomotive cranes are provided for unloading and handling coal at 28 plants out of 41, while 16 report bridge cranes. Boiler refuse is dumped direct into cars in 15 plants, while only 7 dump into conveyors.

Station Heat Balance

The trend in design is more and more toward the use of motor-driven auxiliaries with, in most cases, some arrangement for insuring a continuous supply of power to those auxiliaries commonly classified as essential. The report describes a number of different methods now used for insuring such continuity.

The proper control of motor-driven boiler-feed pumps is causing a number of operators some concern. Statements received from users and also from pump manufacturers indicate that regulators now available for such pumps leave much to be desired. Several makeshift schemes are described, but all have their individual weaknesses or drawbacks.

The advent of the large turbine designed for stage heating of its condensate has resulted in so changing the relationships between different parts of the power-plant equipment that it is felt that information on this subject is particularly timely. For this reason the report includes numerous curves showing the variations in thermal performance resulting from different bleeder and auxiliary arrangements with and without economizers. The economical feed-water temperature when economizers are used with stage heating appears to be higher than one would expect from experience in the older type of plant.

The increasing use of deaërating equipment makes it necessary to consider the effects that such devices may have on the heat balance. This matter is now being studied, and the design being used by one member company is included in this report.

Experience reported by member companies indicates that jet condensers can be used as heaters and at the same time can be operated so as to hold the oxygen concentration to values between 0.10 and 0.25 c.c. per liter. When very low oxygen concentration is desired the condensate and feed water must be handled in such a way that contact with air is practically entirely eliminated. This may be done by maintaining a completely closed system except for a steam-sealed surge tank. One company operating with a steam-sealed surge tank reports condensate running about 0.05 c.c. per liter and boiler feed about 0.50 c.c. per liter, this latter figure including all oxygen picked up by the condensate and brought in by make-up vapor.

The closed heater has been used extensively for the higher temperature ranges. It is now coming into use for bleeder heating, as it offers decided advantages for such work. In particular, the bleeder opening can be connected directly with the interior of the heater without check or non-return valves if provision is made for draining off condensate as rapidly as it forms.

Some designers are now providing for the recovery in the condensate of heat in generator cooling air, heat in turbine lubricating oil and heat in transformer oil.

Steam Turbines

There is given a statistical record of the 1922 performance of 74 large turbine units installed in 27 power houses. The outages of these machines have been analyzed very completely and tables are included which give not only the

numerical values of the various factors reported last year, but also parts of total outages chargeable to different parts of the equipment.

On the turbine 53 per cent of the repair and maintenance time was devoted to the rotating element. A great part of this was incident to replacement of parts to bring the lateral vibration characteristics up to the desired standards determined in research by the manufacturer during the last two years.

On the generator 76 per cent of the repair and maintenance time was devoted to armature and field windings and their cleaning. In the main, dirt is the principal offender. The continual use of fresh air for cooling, no matter how well it may be washed, builds up dirt deposits rapidly. The best solution at hand is closed-system recirculation of air cooled by sprays of cooling coils if the service demands require long operating periods.

On the condenser 83 per cent of the repair and maintenance time was devoted to keeping the tubes tight and clean. To do this work generally requires shutting down the complete unit. Where there is heavy operating demand, the vacuum carried and the economy suffer until there is an opportunity to shut down for such work. Recently installed units are being arranged so that half of the condenser may be opened for cleaning tubes or correcting leakage, while the other half continues to serve the turbine.

Maximum sizes of units have not increased, but radical increase of operating pressure is noted. Units of large size are being produced for operation at a pressure of 550 lb. with steam at a temperature of 725 deg. These turbines are arranged for reheating of the steam about midway of the expansion. In addition, condensate is heated in stages by means of steam extracted from the turbine.

The very general use of bleeder heating of feed water in two or more stages is one of the notable movements of the year.

Condensing Equipment

Control of the quantity of circulating water is considered, and the various methods available for effecting such control are discussed. It is shown that the use of two constant-speed pumps is only a partial solution in most cases, and that variable-speed pumps make possible more economical control.

The maximum permissible siphon is discussed, and records are given showing that one installation operates satisfactorily with a siphon of 32.5 ft. of water. In this connection the submergence of the uppermost tubes is considered and the conclusion reached that under most conditions it is only necessary that these tubes be fully submerged during operation.

Difficulties met with in cases in which the water supply for hurling-water pumps is taken from the circulating-water system are recorded. These experiences seem to indicate a separate tank for hurling-water supply with proper provision for cooling and makeup as the safest arrangement. Two cases are reported in which salt water used in hurling-water pumps has found its way into the condensate and ultimately into the boilers.

The practice of rolling in condenser tubes at one end is reported as entirely satisfactory by several companies. Other operators using this method report satisfactory results, but claim that it takes longer than it does to pack tubes in the ordinary way, that the required tools have very short life and that removal of a tube is a more difficult job than when using packing. Expanded ferrules of several types are described.

Further material has been collected in an effort to determine the effect of grain size on corrosion. It is as yet impossible to draw sweeping conclusions from the evidence available.

Stoking Equipment and Furnaces

Thus far no air preheaters have been installed in this country, although a number of large installations have been made in Europe and one is now being installed in the plant of one of the member companies. This preheater is designed to raise the air 100 deg. at maximum load at the expense of heat contained in the flue gases leaving the economizer.

A study of arches used over chain-grate stokers shows that no general agreement on details of design, size, shape, location, etc., is yet possible. Available life seems to vary from a few weeks to periods longer than one year, and in one instance a life varying between one week and five years is reported for arches of supposedly the same construction, operating in the same plant under what are supposed to be like conditions. Numerous methods of protecting side walls by air cooling and by water cooling are reported, and a few cases are recorded in which special provisions are made for cooling the arch or its supporting metal by means of air.

The demand for a satisfactory regulator which will control combustion in stoker-fired boilers led to a study of the present status of this development. Quite a few plants were found in which some sort of regulator is in use, and some of them report fairly successful operation. However, in no case is a complete system in use, and in all cases reported it is recognized that much improvement is possible and desirable.

Feed-Water Treatment

Results of tests made on deaërators by a member company indicate that with condensate leaving the main condensers with zero oxygen content, the water drawn from open heaters at temperatures in the neighborhood of 180 deg. contains from 0.75 to 1.4 c.c. of oxygen per liter. This material leaves the deaërators at temperatures about 10 deg. lower and containing no oxygen or only a trace. In this plant the use of deaërators has stopped corrosion of steel-tube economizers, which was previously rapid and serious.

Reports from member companies using evaporators for preparing makeup water indicate general satisfaction with this method. Attention is called to the fact that leaky condensers may largely vitiate the results otherwise obtainable, and to the further fact that when the makeup water contains corrosive elements it may be necessary to treat it chemically before admitting it to the evaporators.

Pulverized Fuel

Many trial installations of pulverized-fuel firing have been made during the past year, and this method of firing has been adopted for several large plants now being designed or under construction. Statements by users show that the art is still markedly in a state of flux and that much experimentation remains to be done.

It has become obvious that the superheat obtained with convection superheaters of given size and location is lower when using pulverized fuel than when using stokers. In one case reported the superheat with pulverized fuel was only 125 deg. as against 225 obtained with stokers under the same boiler. The present tendency is toward the installation of radiant-type superheaters in such cases, arranging them in series with the convection superheaters already installed.

Boilers, Superheaters and Economizers

During the year no boiler plants using extraordinarily high pressures or temperatures have been put in operation. The highest steam pressure reported in a plant actually put in service is 300 pounds with a total temperature of about 700 deg. with boilers operating at 200 per cent rating. Note, however, that several plants have been operating for several years at boiler pressures of 350 pounds.

An investigation to determine possible difficulties due to imperfect circulation in wide boilers demonstrated the fact that satisfactory results may be expected if the entering water is uniformly distributed over the width of the drum.

A special study of feed-water regulators was made. Out of over 500 regulators reported on, 83 per cent are reported as reliable. However, comments received indicate that regulators as now built are far from perfect and that much improvement is possible in details of design.

Some interesting data dealing with pressure drop through superheaters and variation of superheat with rating and with CO_2 content of furnace gases have been collected. Variation of superheat with rating and with composition of gas is particularly interesting at the present time because

of the suggested use of convection and radiant superheaters in series. It is claimed that such a combination will do much to wipe out such variations.

Lubrication

The recognized foes of oil lubrication are air, heat, water, light, dust, acids and alkalies, which are fertilizers for the formation of sludge and active contributors to the destruction of the lubricating properties of the oil. It is not expected to render these agents completely innocuous, but at least to adopt every possible means to reduce or mitigate their action to the very minimum compatible with the requirements of a perfected lubricating system, by preventing their unnecessary introduction in the system.

For this purpose the attention of the manufacturer is called to a study of the location and design of oil inlets and outlets, so as to avoid air suction; to prevent oil spraying through orifices discharging through air; to design tight-sealing steam and water glands or packings; and the selection of metals or alloys having the minimum catalytic action for these parts with which the oil comes in contact.

Experiments have been conducted in which the effect of different babbitt metals on the ageing of oil was determined. These experiments showed a marked difference in the characteristics of such metals, some apparently acting as very effective catalyzers, leading to rapid breakdown of the oil. It appears from these tests that turbine manufacturers should investigate the catalytic character of babbitt.

Two forms of sludge are noted. One is the ordinary, well-known variety which settles out comparatively easily and can be more or less perfectly removed by the various clarifying devices now available. The other is a very finely divided material which appears to be soluble in oil at operating temperatures, but which will settle out slowly if the temperature of the oil is reduced sufficiently. It is thought to be the common variety in the incipient stages of formation. No equipment now commercially available will remove it from oil. It has been separated from the oil by filtering through twelve layers of canton flannel.

Attention is called to the fact that it is better to install too few instruments than to install more than can be properly taken care of and used to advantage. Following this line of thought the committee has listed the various instruments in what it considers will be found the order of importance or preference in the average case. Naturally, there is much room for discussion in such an arrangement and local conditions may be expected to have marked effect.

Stacks

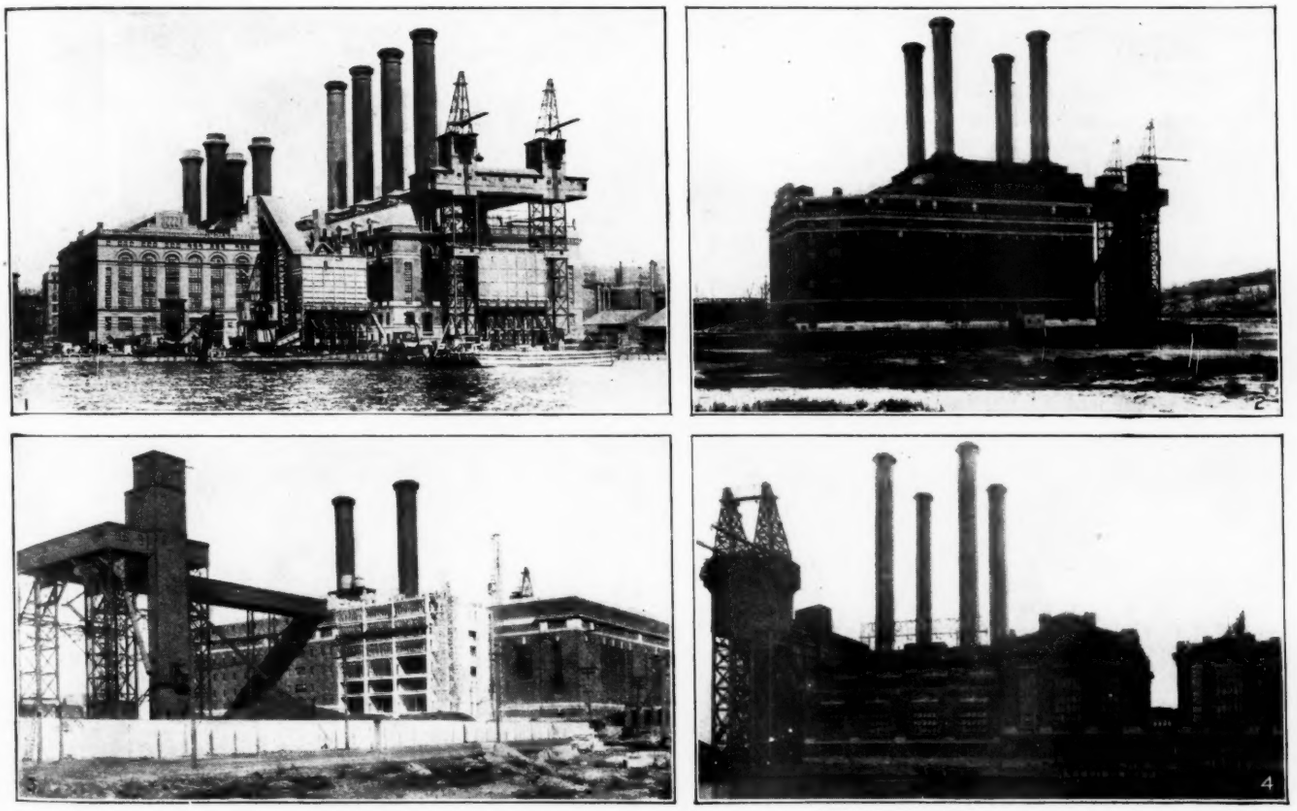
Stacks are considered under four separate headings: Steel, either self-supporting or guyed; radial or common brick; reinforced concrete; and combination of the tile with reinforced concrete.

Steel Stacks—Steel stacks are usually lined the entire length with 4½ in. of second-quality firebrick or with such brick near the bottom and common brick above. In some cases radial brick have been used. The lining is carried on steel shelf angles spaced about 20 ft. apart. In the best practice space is left between the inside of the steel plates and the outside of the brick lining and this space is filled with grout as the work of lining progresses. This grout is ordinarily about 1 to 1½ in. thick. The rapid deterioration of stacks in which the steel has not been protected from acid attack by such a grout filling shows the importance of this feature. The top of lining is covered with a cast-iron coping to prevent rain from seeping into and behind the lining.

The painting of the outside of steel stacks must be periodically renewed, in order to prevent deterioration from external corrosion. This is especially important in warm climates near the sea.

Lightning protection for steel stacks superimposed on the structural steel of the building is unnecessary, but steel stacks resting on masonry foundations with the base of stack above ground sometimes have the base ring connected to a ground plate buried in permanently moist soil.

Brick Stacks—The construction of common brick stacks has been almost entirely superseded by the use of radial



PLANTS AROUND NEW YORK VISITED BY N. E. L. A. DELEGATES

Fig. 1—Waterside stations, New York Edison Co. Figs. 2 and 3—Sherman Creek and Hell Gate stations, respectively, of United Electric Light & Power Co. Fig. 4—Essex station, Public Service Electric Co.

brick. These radial brick are made in a variety of designs, embodying great strength with minimum weight, some of them being more like tile than brick.

Radial-brick stacks are sometimes unlined, but usually are lined for a height of at least 50 ft. above the bottom of flue opening with second-quality firebrick or common brick. The lining is independent of the shell of the stack and rests upon a concrete floor installed in the stack below the flue opening or is carried down to the foundation. Cast-iron copings are commonly provided on brick stacks to protect thoroughly the top course from the weather.

Lightning protection is always required and usually consists of three or more platinum-tipped copper points connected by heavy cable to an ample ground plate buried in permanently moist soil.

Concrete Stacks—The construction of stacks of reinforced concrete has been quite common in the last decade. Such stacks have been built independent of the building in some cases and supported on the building steel in others.

Concrete stacks have not been in general use long enough to establish definitely their reliability and permanence, some engineers still questioning the effect of age and weather on the reinforcing steel.

Foreign Developments.

One of the important events in 1922 in the European power plant field was the putting into operation of the Gennevilliers station at Paris, laid out for five 40,000 kw. units initially and eight ultimately, and designed for steam at about 350 lb. and 750 deg. F. With the boilers and turbines in large units and using steel economizers, air heaters and much other modern, high economy apparatus, the installation is a notable one. This plant is described, and brief mention is made of the new Nechells station near Birmingham, of the older Dalmarnock plant near Glasgow, and of the Golpa and Goldenberg in Germany; these German plants are about 150,000 and 300,000 kw. in size respectively, and thus prominent among the world's large installations. While Golpa was largely designed before the war and would doubtless be quite different if built at the present time, it is of great interest as using lignite fuel of about 4,000 B.t.u. per lb. containing about 50 per cent water.

The great difficulties experienced by most of Europe, due to the scarcity and high price of fuels for power plant and other uses, has led to the wide adoption of certain fuel saving equipment, to the study of by-product recovery, and to the employment of low grade fuels to a degree not yet called for in America. The report mentions some of the many organizations formed in Europe for the purpose of promoting the proper and economical use of all kinds of combustible.

Higher Steam Pressures and Improvement In Station Economy

By Fred N. Bushnell
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DEVELOPMENT in the art of steam-power production is just now proceeding with such rapidity that it is somewhat difficult to preserve a clear conception of its progress. However, the measure of station economy that it already promises can be expressed in the slogan: "A kilowatt-hour for a pound of coal." Designers of power stations and of station equipment are now entirely confident of attaining this mark. They feel that the means for its accomplishment have finally presented themselves, and that only the perfection of detail is now required. One of these means is the use of much higher steam pressures than have heretofore been considered practicable.

We are beginning to realize that the development of materials and methods will permit the use of two or three times the customary steam pressures and that the higher efficiency theoretically permitted by such pressures may be realized without involving temperatures which are unsafe for our materials. Higher pressures can be provided for; higher temperatures must await further development in metallurgy.

There is, however, little net advantage in exceeding pressures of 350 to 400 lb. while using the customary cycle of operation. With the practicable temperatures definitely limited, the increased range of expansion causes the steam to become saturated too early to permit the lower stages of the turbine to perform their function most advantageously. The obvious method of preventing too early saturation is to restore the temperature of the steam by passing it through a reheater at an intermediate point in its expansion.

It is already being definitely planned to use steam pressures up to 1,200 lb. in commercial installations. We are even informed, through the technical press, that for an experimental plant in England, steam is to be generated at the critical pressure of 3,200 lb., where water and steam are one.

We are asked for assurance that the pursuit of higher efficiency through higher pressures is proceeding along lines which are really sound and that this new development promises to secure greater economy in dollars as well as to satisfy the engineers' pride of performance. We are confident that such assurance may be given. Our boiler makers and turbine builders do not question their ability to produce reliable equipment for generating and utilizing steam up to at least 1,200 lb. There is no proposal to exceed temperatures which materials have not already proved their ability to withstand. Surely, our station designers may be trusted to provide the remaining requisites of proper co-ordination and arrangement. An analysis of the requirements shows no problems of a prohibitive nature, nor any measures that may be termed too experimental for commercial application.

The total cost of a high-pressure station promises to be comparable with that of a station of equal generating capacity using the lower pressures now considered standard. The anticipated saving in operation should therefore be practically a net saving. This results from the fact that the extra cost of heavier construction or additional equipment required for the use of the higher pressure will be largely counterbalanced by the additional capacity which is made available. The kilowatt output per rated boiler horsepower will be greatly increased.

We may choose between a single turbine arranged for extraction and return of the reheated steam, the tandem arrangement with high- and low-pressure turbines driving the same generator, and the cross-compound arrangement of two or more distinct units which may be either adjacent or widely separated in the station. Problems of design seem to demand that the pressure for the single reheating unit be limited to 500 or 600 lb. For higher pressures one of the other two arrangements is probably to be preferred. The efficiency of the cycle demands that the reheating be accomplished with the lowest possible loss of pressure. Control of the temperature of the reheated steam must likewise be carefully provided for, especially where a varying load is to be carried.

There is no intention to imply that high steam pressure alone will be responsible for all the promised improvement in station economy. Heating of the feed water by multistage bleeding of the main turbines is an important measure still remaining to be fully applied. Auxiliaries must be more carefully selected to reduce their power demand at all station loads, and such power should be derived from the main turbines where it is most economically produced.

As the means for securing higher economy have increased in number, there has also been an increase in the complexity of their inter-relation. More than ever will the over-all result depend upon their proper co-ordination for the conditions to be met. By utilizing these available means and with their harmony of operation assured, the performance of even a 350-lb. station may, under favorable load, approach within a fair range of the immediate goal that we have set. It is by adding the further improvement of about 10 per cent, which calculations promise for the change to 1,000 lb. pressure and the reheating cycle, that we may deliver a kilowatt-hour for a pound of good coal.

Pulverized Fuel In Central Station Boiler Rooms

By A. G. Christie
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A PRIMARY consideration in central stations is the reliability and dependability of the fuel burning equipment. At the present stage of development there seems to be little, if any, difference in mechanical dependability between the better stokers and pulverized-coal equipment. There are some stations, for instance, where certain classes of anthracite will be burned, in which stokers might give more satisfactory service. However, mine sweepings and low-grade bituminous coals with a high ash of low fusing point, can be burned in powdered form with less effect on the steaming capacity of the boilers, than with stokers. This ability to use low-grade coal is an important advantage of pulverized-fuel systems. Furthermore, a change may be made from one coal to another and the boiler efficiency maintained with relatively few and simple changes in the rate of feeding coal and in the air supply.

Load can be picked up or dropped more quickly with pulverized fuel than with stokers. Quick pick-up has an economic value and a good service value each time that the station load comes on suddenly. The fuel supply can be shut off almost instantly when the load is taken off the boiler. Hence stand-by losses are small as compared with stoker equipment.

Pulverized-fuel equipment as now developed may require a higher average quality of attention than stoker equipment, for with the former, fire conditions can vary with great rapidity. There is need of further development of apparatus for controlling and regulating coal and air supply, and furnace conditions with powdered coal. The sustained efficiency of boilers with pulverized coal depends upon the effectiveness of coal feeders and control systems, and considerable improvement may be expected over the devices now in service.

Probably the greatest advantage claimed for pulverized fuel is the fact that it can be burned with less excess air than is usual in stoker practice. This results in lower flue-gas temperature and, therefore, in higher boiler efficiencies. It may be possible to further increase this advantage by lining the sides of pulverized-fuel furnaces with radiant heat-absorbing surfaces which will form part of the boiler. This construction will greatly decrease furnace maintenance. With such an inclosed furnace the combustion air may be highly preheated and in fact should be so preheated if highest over-all station economy is to be secured. Now mixing and feeding devices may need to be developed to realize the fullest advantages of preheated air in such a furnace as just described. The use of preheated air in improved burners may influence the size of combustion chamber now in vogue.

Higher boiler efficiencies over a greater range of load may be secured with pulverized coal than with stokers. In fact, continuous boiler and superheater efficiencies (exclusive of economizers) of 80 per cent or more may be maintained in properly constructed boilers and furnaces over a considerable range of load above and below 200 per cent rating. This is somewhat offset by the power required by present-day equipment for pulverizing, transporting and feeding the coal. More economical pulverizing equipment is greatly needed in units of larger capacity than now available. The use of flue gas for drying coal is proving satisfactory, and in addition, it results in an improvement in plant economy of about 1 per cent.

Little ash settles in a pulverized-coal furnace, and this is more easily and cheaply removed where effective water screens are used than the ash from stokers. The ash passing off in the flue gases is, however, more difficult to recover than cinders in the flue gases from stokers. In some districts it may prove objectionable to permit such ash or cinders to pass up the stack. The equipment required for efficient ash removal from flue gases and the power for its operation may be larger items of cost in a pulverized-coal station than the removal of cinders from the flue gases in a stoker-fired station. In a well regulated furnace with pulverized fuel, little carbon can be found in the ash and this represents a saving over stoker operation.

Pulverized-fuel furnaces may be readily adapted to oil or gas firing should occasion require. Such a contingency may occur in the near future if complete gasification processes with byproduct recovery becomes economically desirable.

While great progress has been made in the development of pulverized-coal equipment and great credit is due to those who have persevered in this work, it will be obvious from the preceding paragraphs that this method of burning coal lends itself to further improvement over a wider range of conditions. There is a great danger of too rapid adoption of under-developed pulverized-coal equipment in unfavorable places, by over-enthusiastic designers, which may cause great losses to the industry and may seriously affect rational development along sane and sensible lines based on accumulated data and experience. Furthermore, location, fuels available, character of load, cost of labor and load factor are of primary economic importance in deciding on a fuel burning system.

Each power plant, therefore, presents a separate economic problem, and at the present stage of development in every case one can determine only after careful study of all factors, whether pulverized-fuel equipment has sufficient advantages over one or other form of stoker to warrant its installation in that particular plant.

Obsolescence A Factor In Power Plant Design

By Peter Junkersfeld
McClellan & Junkersfeld, New York

TWENTY years ago a new era in power-plant design began with the advent of large steam turbo-generators. During this period the steam pressures in use at the throttle have increased from about 200 to 300 lb., and the total temperatures from about 500 to 700 deg. F. The improvements in economy have been rapid, large and continuous during this period.

Today we are either in the last stages of the old era or in the early stages of a new era, particularly in the design of steam-power plants using coal as fuel. The innovations consist of three general groups: (1) More economical combustion of fuel, (2) more economical generation and delivery of steam, and (3) better utilization of steam.

In the first group one of the most conspicuous innovations is the burning of coal in pulverized form, which for the prevailing coal in many sections and under certain local conditions, is now being installed at approximately the same total cost per developed boiler horsepower for boiler-plant equipment and building complete as the stoker fired boiler plant and building complete for the same character of coal, and under the same local conditions and with substantial gain in efficiency.

In the second group and dealing with the generation and delivery of steam, we observe for instance, inclined-tube boilers being installed, some only 9 tubes high, and up to 24 tubes high, varying in length from 18 to 25 ft. Superheaters, both convection and radiant-heat types, are being placed in several different locations with respect to boiler and furnace, with wide differences in design. Economizers have also been changed considerably in design and materials. In the treating and heating of boiler-feed water (including condensate), long neglected, substantial progress is now being made, as reflected in various heat-balance arrangements. In many cases this requires the development of new or modification of available apparatus such as evaporators, heaters for receiving steam extracted from various stages of the steam turbine, deaërating apparatus heat exchangers, equipment for continuous bleeding of boilers to reduce concentration and obviate blow-down losses and the like.

The third group is concerned with the so-called higher steam pressures of 400 and 550 lb., requiring smaller tube

diameters and different design of boiler than for pressures under 385 lb. Extra-high pressures of 1,200 lb. require heroic departures in design. All these pressures also involve various degrees of departure from present designs of turbines, accessories and piping, as well as boiler-feed pumps and other boiler-plant equipment.

Larger reductions in fuel consumption may be possible under the third group of innovations than under either of the first two, but on the other hand these also involve larger increase in investment costs than those under group 2 and greater risk of interruption to service and increased maintenance, because much of the innovation is in the piping, valves, packing, etc., which can be developed only in the going plant. As a practical matter any central station adopting higher steam pressure would also adopt many of the innovations in groups (1) and (2).

In five, ten or twenty years hence it will probably have been found that the amount of money necessary to cover obsolescence and supersession of part or all the elements in each group will vary considerably. Obsolescence as here used means the "going out of use" or the lesser and lesser use over a period of years. Supersession as here used means "the act of superseding, or setting aside."

Obsolescense is likely to affect an entire unit such as a turbo-generator together with its condensing equipment and other accessories, or a complete boiler or groups of boilers and accessories. Supersession is likely to affect some one or more of the least dependable, least adequate or least efficient elements of such a unit and would be immediately followed by replacement with an improved element.

During a period of pronounced development in the art it frequently pays a large central station, whose business is increasing rapidly to supersede elements and sometimes complete units long before they become obsolete. Supersession and obsolescence are sometimes greatly increased by a too early use of innovations and sometimes even more increased by a too late use.

The primary object in these various innovations is better fuel economy. The fuel savings during the life of equipment under discussion may be partly or wholly offset by other costs and probable charges. We must be not only B.t.u. savers, but also real dollar savers.

A savings and loss balance should include fuel, operating and maintenance labor, supplies and adequate fixed charges on the investment. The coal savings will vary with the cost per million B.t.u. of coal, and with the daily and yearly load factor at which the equipment is operated in each year during its life. This life used in determining the savings side should be the same as the life used in determining the "extra fixed charges" on the loss side of the balance.

The fuel savings must obviously be placed on a per kilowatt-hour basis because the amount of fuel used varies principally with the kilowatt-hour saleable output. To have a true balance the extra fixed charges should also be placed on a similar kilowatt-hour basis.

The determination of fixed charges on investment is one thing, but of "fixed charges per kilowatt-hour" is quite another matter. A curve of the latter would be much higher with some companies than with other companies, based upon three items: (a) Extra construction cost; (b) percentage allotted for interest, taxes, depreciation, etc.; (c) the kilowatt-hours per year over which the number of dollars resulting from (a) and (b) may be spread.

The effect of item (c) on extra fixed charges per kilowatt-hour is so much greater, that for the purpose of this discussion we may assume that item (a) and item (b) are both constant for a number of central stations whose extra fixed charges per kilowatt-hour we may wish to determine. We then have only one principal and easily obtainable factor to deal with—namely, output—or as it has been more specifically defined, "Generator Capacity Factor," which is the ratio of the actual output to the possible output of a steam turbo-generator as rated and all its accessories when averaged over a period of years, especially among central stations which have a substantial annual average increase in output, is much lower than usually supposed.

An examination of the experience of eight companies with 18 power stations and 113 steam turbines, aggregating 2¼ million kilowatt rating shows that in the same two-year period one company had an average generator capacity factor on all its turbine units of 46 per cent, and two of only 22 per cent. The extra fixed charges per kilowatt-hour for the latter two would be more than double that of the former. This difference indicates a wide variation in design, management and operating practice, and local conditions.

It was also noted that only two companies had an annual capacity factor of 60 per cent or better on any one turbine. There were only three turbines 18 years old and only 24 turbines more than 13 years old, all belonging to three companies, still available for use.

The following average combined experience table for these 8 companies, all in large and growing cities, shows the capacity factor for all turbines of the ages indicated:

COMBINED AVERAGE EXPERIENCE TABLE—GENERATOR CAPACITY FACTORS, 1921 AND 1922

8 companies; 113 turbines; 2,261,000 kilowatt total rating.

No. of Turbine	Years Old	Percentage
9	1	45.2
21	2	50.8
18	3	49.5
13	4	46.5
10	5	42.7
7	6	39.5
10	7	31.8
15	8	35.2
13	9	20.9
16	10	25.6

Experience has shown that on a rapidly growing central station system the so-called "base load" unit or station enjoys that distinction only until new and better units rob it of the honor, and which is frequently within five years.

Some of the innovations now being considered might, under a certain set of conditions show a large net saving with $6 coal of a given quality, and a net loss with $3 coal of the same quality and under the same set of conditions. Again, in order to perform our full duty we should be real dollar savers and not solely B.t.u. savers.

High Pressures and Superheats in Great Britain*

By Charles H. Merz
Consulting Engineer, Merz & McLellan, London, England

MANY rumors have been afloat as to the operating difficulties in the North Tees Station designed by our firm in 1917. This station's boiler pressure was at that time unprecedented. Ordered toward the end of the war, the turbines for this plant were necessarily made according to designs that would not have been acceptable during normal times. As a result trouble developed with the turbine cylinders, which had to be replaced at a time when the utmost was being demanded of the plant in the way of service. Under these strenuous circumstances the personnel did not feel warranted in taking time to give the engineering public the details of the operating difficulties. In spite of rumors to the contrary it may now be definitely stated that none of the trouble first experienced—and now remedied—can possibly be laid to the "advanced" features of this plant. The high pressure (500 lb. at the boiler), air heaters, stage reheating and bleeder heating have all been an unqualified success.

The question is sometimes asked "Are not water economizers better than air heaters?" The question is not pertinent in the case of a station where bleeder heating is used to the limit, for the simple reason that there is no heat left to be supplied by an economizer. The air heater is the only other way to recover waste heat from the flue gases. Incidentally, an air heater gives less trouble than an economizer and is cheaper to operate. Bleeder feed heaters cause no trouble.

Our firm has always regarded the house turbine as a makeshift, on account of its inefficiency. With high pres-

*This is an abstract of Mr. Merz's remarks.

sures there is even less excuse for a house turbine. Where auxiliary motors cannot be safely operated from the main bus, they can be supplied (at least in large plants) from a small auxiliary generator on the shaft of the main turbine. As a possible substitute for the house turbine engineers might give consideration to some highly efficient form of internal combustion engine.

Discussion

THE chief topic of the discussion that followed the papers was the question of high pressures. In general it was held that pressures up to 1,200 lb. would pay with the reheating cycle. Other subjects mentioned were heat insulation and motor-driven auxiliaries.

In reference to Mr. Bushnell's paper on high pressures, V. T. Malcolm, of the Chapman Valve Mfg. Co., stated that high temperatures could safely be used along with high pressures if proper attention were given to the materials used in valves, etc. Good steel, he said, would give no trouble at 800 deg. F. In fact, sets have operated satisfactorily in oil-refinery work at 1,200 lb. and 1,000 deg.

Confidence in the successful adoption of high pressures was the keynote of the remarks of Oscar F. Junggren, of the General Electric Co. Troubles would, of course, be encountered, but they probably would not be found where most expected. Most of the high-temperature dangers would disappear as soon as the question of expansion was attacked by designers in a rational manner. More attention, he said, should be given to the matter of steam flow. Pressure drops in pipe lines were unnecessarily high. Turbines could easily be designed for pressures of 1,200 or even 1,500 lb. In fact the turbine manufacturers were only waiting to be asked.

Francis Hodgkinson, of the Westinghouse Electric & Manufacturing Co., said that his firm was standardizing on single-cylinder machines up to 400 lb. Above that they compounded a special high-pressure unit with a standard unit, thus putting the experimental portion of the apparatus in a small separate unit. Mr. Hodgkinson was not certain that reheating was essential and suggested the mechanical removal of the moisture with the bled steam. Where reheating was employed, an additional control valve should be placed on the low-pressure unit to take care of the large steam capacity of the reheating apparatus and piping.

A. C. Flory, of the Allis Chalmers Co., invited the members to inspect the first 20,000-kw. steam turbine constructed by his company. This turbine is soon to be placed in the Waukeegan plant of the Public Service Company of Northern Illinois.

L. L. Barrett, research engineer with Keasby & Mattison, referred to the calcination of magnesia heat insulation at high temperatures, as mentioned on page 14 of the Prime Movers Report. He stated that while some calcination occurs at high temperatures, its seriousness was often exaggerated. Calcination, he said, reduces the weight and increases the insulating efficiency.

Comparison of American and European Hydraulic Turbine Practice

By H. Birchard Taylor

Vice-President, Wm. Cramp & Sons Ship & Engine Building Co., President, The Pelton Water Wheel Co.

THERE is no question that as far as magnitude and number of installations are concerned, American engineers have been pre-eminent. As a result of our great water-power resources coupled with the demand for power, turbines of unprecedented dimensions and capacities have been developed by American engineers with unqualified success, and in this factor American installations are far in advance of those in Europe.

Although large increases in turbine dimensions involve important mechanical problems, the question of hydraulic design is not so greatly affected, since the results of experiments have shown that turbines of homologous design of widely varying size give consistent results and that when the continuity of flow is not broken up by improper location of the turbine in respect to tail water, engineers may predict the performance of units of large size on the basis of tests made on models of greatly reduced dimensions. Independently of considerations of sizes of installations, it is believed that from the number and value of improvements in essential features of the hydraulic turbine, and including radical changes in turbine types, and from the degree of excellence attained in turbine performance, it may be concluded that turbine design has reached a higher state in America than in Europe and that the center of gravity of the art has been moved to the continent.

No one should discount the value of the contribution of European engineers during the last thirty years to the theoretical knowledge of turbine design, for until about 1905 the turbines for the more important installations in this country were largely influenced by theoretical methods derived from Europe. While an elaborate theoretical structure covering the field of turbine design had been developed in Europe, a development of an entirely different sort had taken place in America. On the other hand, while theoretical analysis had been but little developed by many American waterwheel manufacturers, the early American engineers in this field, had chosen a firm basis for their work; namely, the submitting to actual test of models of the wheels which they produced.

Unfortunately, European engineers were inclined for a long time to belittle the dependence placed upon experiment by American engineers as merely a "cut-and-try" method. Nevertheless the turbines so produced greatly exceeded in specific speed any designs produced in Europe, and a number of these turbines were unapproached in efficiency by any European wheels. Modern American practice is a different proposition from that of the early period, but our present engineers in this field still show a characteristic predilection for experimental checking of their theories, a method which is believed to be the only sound procedure and one which it is hoped will never be abandoned.

In a number of features European turbine development has proceeded along lines closely parallel to that in America in recent years. The two lines of practice have tended to come closer together as the art advances. The propeller-type runner, which was a feature of some of the early American turbine types, has been actively developed in both Europe and America. In the size and number of installations and the efficiencies secured, America has in the last three or four years taken the lead in this development.

In the development of the draft tube, American engineers have outdistanced those of Europe. One of the most recent statements from Europe, giving the results attained with a European propeller runner, presents a maximum efficiency of about 81½ per cent with a specific speed[1] at the maximum efficiency of 140. These results were obtained, however, on a model having a draft tube of such length that it could not be homologously reproduced in an actual installation of any size. In contrast with this result, a Holyoke test on a diagonal propeller-type turbine of 153 specific speed showed a maximum efficiency of 88.7 per cent, the turbine being equipped with a spreading-type draft tube, developed in this country, in proportions geometrically similar to a full-sized installation. The same turbine with a runner of 112 specific speed, gave an efficiency of 90.7 per cent; in the higher specific-speed field an efficiency of 85.5 was obtained on a runner of 180 specific speed. In the article from which the foreign results of European tests were taken efficiencies of 75 per cent for 180 specific speed are mentioned with approval. In American practice efficiencies of 75 per cent or even 85 per cent would not be given consideration save under exceptional circumstances, no matter how high the specific speed might be.

Both the draft tube and the propeller-type runner have received more thorough theoretical and experimental study

[1] Foot-pound system.

here than in Europe. Certain misconceptions might be mentioned which have handicapped some of the engineers dealing with this subject both in Europe and America—for example, the idea that the laws of hydraulic similarity fail to apply to the propeller-type turbine, while applying to every other hydraulic machine. This fallacy has arisen from attempts to apply runners of inadequate blade area, and consequent excessive intensity of pressure reduction behind the blades, to installations where the runners have been placed too high with respect to tailwater. The formation of voids in the water column below the runner in such circumstances causes a change in the flow through the turbine. Up to the critical point where the continuity of flow is thus destroyed the laws of hydraulic similarity are strictly applicable; beyond this point the turbine should not be used at all. The trouble is not with law, but with the form of the turbine.

In the high-head field the Pelton wheel, a purely American product, has for many years superseded all other types of impulse wheels in both Europe and America. New innovations in the impulse field have recently been proposed in both Europe and America. As to which line of attack will prove the more successful, time will tell, but the writer is confident of the strong possibilities of the new types proposed in this country.

Electrical Apparatus Report

AS NO radical developments in design and equipment have taken place during the year, the activities of the committee have been largely devoted to gathering data on engineering and operating practices. Probably the most important work accomplished this year has been the cooperation of the sub-committee with the Fire Underwriters' Bureau, which is issuing a treatise on the question of generator fire-fighting equipment. It has been difficult, in the past, especially in small companies, to determine the simplest and best equipment for protection against fires and to convey to all the thought of the necessity of installing balanced relay protection on all units.

Twenty pages of the report are devoted to alternating-current and direct-current substation practice and cover this subject thoroughly. An important detail of this part of the report is the information received from 15 companies reporting, in detail, on the important features of design of indoor industrial substations, sometimes referred to as transformer vaults. All this information has been gathered in two large tables giving data on the line room and on the transformers.

One of the marked tendencies in direct-current substations, developed in recent years, has been a gradual reduction in the use of synchronous converters and batteries on some Edison systems and the substitution of motor-generator sets serving local areas. One company reports trouble in operating 25- and 60-cycle converters in parallel on the same bus. A detailed analysis of the trouble experienced indicates that the synchronous converters supplied from different alternating-current systems of the same or different frequencies, not tied together, will operate successfully in multiple on an Edison system when connected to the network through separate feeders; but when connected with the same bus a machine is likely to invert.

The results of a series of tests made on large turbo-generators, have not yet been made public, but from the data obtained, and also considering the discussion of this subject at the 1922 convention of the A.I.E.E., it seems that two noteworthy steps will shortly be taken. First, the agreement of the manufacturers to design machines for radial ventilation and a maximum temperature of 125 degrees C. (80 deg. C. observable rise) instead of the present dual standards of 105-150 deg.; second, a standardization of the use of 20-in. embedded temperature coils for all generators, instead of the present dual standards of temperature coils and thermocouples.

In reply to a request for information on methods of voltage regulation in power plants, 29 companies furnished data. Of these 12 used automatic regulation and 7 a combination of hand and automatic regulation. In general, the procedure is to operate the large plants by hand and the small plants by automatic regulation.

In practically all of the newer stations and those now under construction, electric drive has been adopted for a very large proportion of the auxiliaries. The preference for the supply of energy from the main bus only as compared to supply from a combination of house turbo-generators and house-service transformers, has shown a definite trend toward the latter, because the advantage of independent sources of supply and adaptability of heat-balance adjustment.

The only outstanding new feature in this connection is the adoption of a direct-current shaft-driven auxiliary unit for supplying excitation and condenser auxiliaries or alternating current for supplying auxiliaries only.

In the last two years the possibility of starting squirrel-cage motors directly across the line in the larger stations, where there would be no objections from the viewpoint of voltage fluctuation, has been discussed. In the Calumet Station, Chicago, several motors up to 150 hp. are regularly started in this manner. As to the ability of the motors themselves to withstand the severe duty of starting under these conditions, the manufacturers state that most any motors meet this condition successfully, but to guard against undue deterioration from frequent starting under this severe duty, it is recommended that each individual case be referred to them before purchase is made.

The question has lately arisen whether synchronous motors should not be used more widely by central stations in their plants in order to improve the power factor of the auxiliary load and to be in accordance with the general policy recommended to customers. While the economies obtainable are not quite comparable, the psychological effect would be helpful. An example of the use of synchronous motors for circulating-pump drive is the Harwood plant of the Pennsylvania Power & Light Co., where three 500-hp., 2,400-volt motors are in satisfactory operation.

A canvass of numerous operating companies indicates a number of centrifugal-transformer oil purifiers in service. Many report complete satisfaction with this equipment, several report this method slower than the blotter press, while others report using the centrifugal machine as a primary purifier, finishing up with one run through the blotter press. It appears that the temperature of the oil when put through the centrifugal machine exerts an exceedingly important influence on the rate of filtration or capacity of a given machine and dielectric strength of the filtered product. Apparently, the oil-heater capacity of the machine originally introduced has been insufficient.

Other features of the report of the committee were: Temperature indicators for turbo-generators, experience in fire-fighting equipment for turbo-generators and exterior color treatment of transformer cases, which will be treated in separate abstracts in early issues.

Hydraulic Power Report

ABOUT two-thirds of the report, this year, deals with penstock design, and covers 50 pages. An effort has been made to collect as much data as possible on the practice of various companies and engineers in the matter of designs of penstocks.

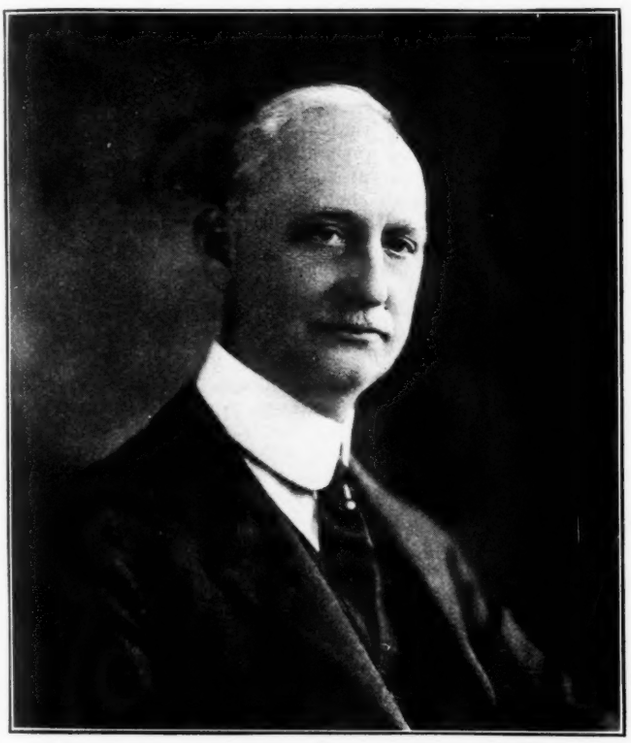
The general tendency seems to be to limit the maximum velocity in the penstock to 10 or 12 ft. per sec. This is probably due to the fact that the majority of plants are of moderate heads. In high-head plants, the maximum velocity will be nearly double these values, if the pipe is designed on an economical basis. Several high-head Western plants have velocities of from 15 to 21 ft. per sec., and pipe lines are now being designed for even higher velocities. This is more nearly in accord with the practices in Europe and Japan. Many pipe lines of high velocity have been in operation several years, and no deterioration of the pipe or other objectionable result has been noticed.

The report goes into the question of buried versus exposed pipe, to considerable extent, and a separate abstract will be published covering this.

It is considered good practice to install a standpipe

immediately below the valve placed at the upper end of the penstock. This standpipe should be of sufficient size to admit all the air required to prevent the collapse of the pipe under the worst conditions of flow. This case would occur with free discharge at the lower end of the line and the valve at the top closed. It is generally believed that the air flow through a standpipe or air valve should be calculated on the basis of half the difference of pressure that the pipe can safely withstand without collapse. The installation of the air valve will depend entirely upon the profile of the line. In general, air valves are located on summits or at abrupt changes of grade, where there is a possibility of the water column separating on a suddenly accelerating gradient, or where the hydraulic grade lines closely approach the level of the pipe line.

The use of welded pipes for important penstocks is rapidly increasing. This is largely because the great improvement in manufacturing methods insures a uniform product. For penstocks welded pipe is practically limited



FRANK W. SMITH, RETIRING PRESIDENT

to that made by a forged welding process; autogenous welding is not considered reliable enough for this class of work. In recent years the price of welded pipe has been greatly reduced, so that a pipe designed on an economic basis will consist of a great percentage of welded pipe. In fact, some lines that are now being built are of welded pipe only, as an economic investigation showed that the welded pipe was cheaper to install and rivet.

Only one failure of recently laid welded pipe has been reported. An investigation showed that this was due to a flaw in a steel manhole casting that had been welded into the pipe. In this case, however, no evidence was found of any failure of the weld itself. The welding of steel casting should never be permitted; all castings to be welded to the pipe should be forged steel. Several failures of old pipe lines have been noticed, but these have been found to be due to the method of manufacture, which was not at all developed to the point at which it is today. It is universal practice to consider the efficiency of the weld as 90 per cent. This is the value guaranteed by the manufacturers, but innumerable tests show that the weld is practically as strong as the plate. The general belief is that wood pipe should not be used in a permanent installation for greater heads than 100 ft. Instances have been given where small pipe has been used successfully on heads of 400 ft. and 600 ft., but in general these are only for construction plants.

Experience on the large wood-stave pipe installations show that if the pipe is empty and then filled, there is enough change in shape from the circular to cause some leakage through the staves. In two installations, the penstocks were sprayed with a cold preservative paint at the end of five years' service. This was done primarily to protect the bands, but also proved useful in penetrating the checks and cracks in the wood and practically stopped leakage.

Methods of forecasting water supply have been gone into quite extensively in the report and the opinion is expressed that in too many cases, water-power developments have been made without a thorough study of the discharge of the stream and its storage possibilities, resulting in an overdevelopment with perpetual excessive overhead expense or an underdevelopment requiring large capital outlay to bring it up to full development.

Many methods have been used to forecast supply, daily, weekly and seasonally, and for the purpose of this report the subject has been divided into four sections, as follows:

1. Forecasting the average run-off of streams for which no discharge records have been kept from precipitation records.
2. Seasonal forecast of stream run-offs or impounding reservoir storage from precipitation records.
3. Seasonal forecasting of stream run-offs or impounding reservoir storage from snow surveys.
4. Forecasting precipitation from records of ocean temperatures.

While snow surveying for the purpose of forecasting water supply has not yet been generally practiced, it has been practiced to some extent for over ten years in Utah, Nevada and California, and in Switzerland. Two principal methods have been developed—the percentage method and the method of areas. The percentage method consists essentially of a determination of a percentage variation from the normal of the water content of the snow blanket and the assumption that the stream run-off from these snow fields will have the same variation from normal. The method of areas consists in dividing a watershed into areas and by sampling the snow in each area, determining the number of acre-feet of water in the whole snow blanket.

A third method is that of accumulated snowfalls, from which only approximate results may be expected. A fourth method, approaching in accuracy and being somewhat cheaper than snow-surveys, consists of determining the depth of snow on the ground. It does not take into account the density at the time of measurement and will vary from season to season with the winter weather, particularly the temperature and the wind.

Danger of Halting Water-Power Development

By O. C. Merrill
Executive Secretary, Federal Power Commission

PRIOR to the passage of the Federal Water Power Act projects involving some 1,400,000 hp. had been constructed under authority given by the Federal Government. Of this amount about 800,000 hp. may be credited to the public lands and reservations, 200,000 hp. to the boundary streams, and the remaining 400,000 hp. to interior navigable rivers. Of the latter amount, slightly more than 60,000 hp. was developed after 1906. This was the aggregate accomplishment during a period of more than twenty years.

The Federal Water Power Act has been in force less than three years. The new construction already completed or involved in projects upon which construction has already started aggregates 1,470,000 hp. of proposed installation. In certain cases, of course, these figures represent a construction program extending over several years; but new projects are constantly being started. The aggregate total of estimated installation in the 173 projects for which permit or license has been issued or upon which immediate approval may be expected is 7,600,000 hp.

There is no existing power surplus. To meet the increasing demands of industry without increasing commodity costs or lowering social standards will require constantly increasing amounts of power, the substitution of electric drive for less efficient forms of energy application, the displacement of manual work by mechanical work, and the diversion of labor into employments where more than mere manual dexterity is required. We need more electric energy; we need it in larger units; we need it distributed more widely and efficiently.

We must conclude, therefore, that neither any surplus of power, nor any failure of the Federal Water Power Act

WALTER H. JOHNSON, PRESIDENT-ELECT

to protect the public interest or to give adequate opportunity for private investment, can justify any retardation in the progress of water-power development, or any essential modification in the existing law. And yet what do we find? Right about us here is our greatest industrial section, capable of absorbing millions of kilowatt-hours of new energy, and within transmission distance of the greatest source of water-power on this continent—the St. Lawrence; and yet the waters of this river are running unused to the sea. Across the continent lies the Colorado, our second greatest potential source of water power, capable of energizing the whole Southwest, and no more used for that purpose than in the days of the Spanish Conquest. Many other less important instances could be cited. No lack of demand for the energy and no lack of capital able and willing to produce the energy, is preventing development in these instances. Development is being blocked by conflicts over jurisdiction, by interstate jealousies, by strife between public and private ownership, by existing or prospective embargoes on power transmission, by attempts to secure special advantages or privileges, or by restrictive state legislation.

Certain state legislation, enacted or prospective, has placed or is seeking to place unnecessary restrictions on power development. One state, in fact, is proposing to forbid for a period of years the grant of any authority for new water-power development while it makes a survey of its power resources. Others have proposals for reversion of property to the state without compensation, for special and excessive taxation of water-power development, and of grants or franchises of too short a duration to justify the expenditures which large-scale power development requires. What the effect of such legislation must necessarily be has been abundantly proven by the almost complete cessation of new construction under the Federal Acts of 1906 and 1910.

Another policy which is checking power development is state embargoes on the export of electric energy Manifestly such embargoes are only artificial trade barriers erected at state lines. From a legal standpoint it is difficult to perceive how a provision which seeks to stop trade altogether is less repugnant to the Federal Constitution than a provision which seeks to stop it only in part by a levy of export duties; and the latter is prohibited in specific terms.

Another deterrent factor in power development is the strife between the policies of public ownership and of private ownership with public regulation; or rather, the efforts of advocates of the former to prevent or limit through political pressure the development under the latter of the water-power resources of certain states. I am not a partisan of private ownership or of public ownership as such. It may be well that these two systems should be tried out side by side until their comparative merits can be established to general public satisfaction; but if so, their respective merits should be determined on a really comparative basis, with public ownership measured by precisely the same standards as are applied to private ownership. The primary public concern is to secure the most widespread and most satisfactory service at the least price to the consumer. If public ownership can produce these results by honest competition rather than by political assault, it will and should survive. In view, however, of the character of our political institutions, I seriously doubt if public management can, except in rare instances and under special conditions, compete in character or cost of service with private management publicly regulated, particularly when we take into consideration the economic necessity of grouping developments into systems extending beyond the jurisdiction of any state.

If you gentlemen of the industry are to maintain your position you must demonstrate to a still somewhat skeptical public that you can give a better service, that you can do it at less cost, and that you can and will pass on the economies of private management to the consumers.

We have in the Federal Water Power Act a national policy determined only after years of deliberation, representing, if any legislation ever did, the mature judgment of Congress and the consensus of public opinion. If we are to preserve this policy intact, to protect it against essential alteration or the establishment in state or nation of antagonistic principles, are to secure for all the people the benefits of the extensive development which its unhampered administration would secure, we must remain at all times on our guard.

President Smith Pictures Optimistic Outlook

A general survey of the conditions in the electrical industry throughout the country was given by President Frank W. Smith in his address at the opening session Tuesday morning. The electrical output, he said, has doubled every five years for the last three five-year periods and the indications are that there will be no diminution in demand for some time. His remarks were in part as follows:

Power is essential to industry, and the growth in physical volume of production at present indicates a rate of industry recovery almost without parallel in American business. The volume of goods produced and passed into consumption during the first five months of the current year probably exceeds that of any similar period in the Nation's history, and the course of business activity during the last three months has been definitely outweighed.

During the first four months of this year, the electric light and power industry raised for all purposes 60 per cent more money than it did during a similar period of 1922, indicating that for the current year bond and stock quotations will reach over a billion dollars as compared with 750 million last year. The output of electrical industries for the first three months of this year show an increase over the first quarter of last year of nearly 33 per cent. The questions that have been raised with regard to industrial activity as to danger of overexpansion do not apply to the electric light and power industry.

Statistics compiled by the government show that the average daily consumption of fuel by electric light and power companies during 1922 was slightly less than for the average of 1919, yet there were thirteen billion more units of electricity generated in 1922 than in 1919, showing a saving of at least fifteen million tons of coal due to the greater efficiency of the electrical utility plants in the utilization of fuel. This saving of fuel has partly offset the increased cost of labor and material, thus lessening the adoption of increased rates which would ordinarily fall on the consumer.

In the development of the Nation's resources, and in their economic utilization, the electrical industry has not been amiss; it has given to the United States leadership in this respect. Almost half of the total water-power development of the five continents is within our boundary. Moreover, in the efficient use of coal and other fuels for the manufacture of electrical energy the United States stands at the head of the list.

American Boiler Manufacturers Association

IN opening the thirty-fifth annual convention of the American Boiler Manufacturers Association at Hot Springs, Va., last week, President A. G. Pratt said that now that the period of better business has arrived, we are perplexed to know how long it will last and have become cautious concerning the future, in view of the pyramiding of material prices, high wages and the difficulty of obtaining material and labor. It seems inconceivable that business can fall to the depths reached in the latter half of 1920 and 1921. There is no over-extension of credit; corporate as well as governmental finances are in satisfactory shape, and the banks are in good condition. There is and has been little, if any, production in excess of requirements. Stocks of all commodities are low, and many improvements, public and private, are merely held up until they can be undertaken without bidding against today's necessities.

It is to be hoped that a definite tax policy may some day be adopted which will be adhered to, rather than to subject the nation to constant changes in the laws, which make planning ahead difficult and uncertain.

He did not wish to see an industrial or business "bloc," but did feel that industry and industrial leaders should take a great interest in governmental affairs. An encouraging feature is the interest of the Department of Commerce in business. This is not interest of a regulatory character, but one which is calculated to benefit American industry, both at home and abroad, and through the benefit to industry to benefit the nation. If business desires a greater share in government, it must do everything possible to make the work of the Department of Commerce successful.

The boiler industry, in common with others, is suffering from a lack of labor, both common and skilled, although the chief shortage is in unskilled labor. The increases in wages caused largely by this condition will not increase the available supply of labor, and can only result in extremely high rates without enabling us to obtain or hold men. Decreased production through lessened efficiency of the men leads to a hardship upon labor itself, due to the higher cost of living, a stoppage of buying and the eventual lack of business and of employment. Some employers would like to see all immigration restrictions removed. Labor leaders and others insistent that the present minimum be decreased. Mr. Pratt felt that neither of these extremes was right, but believed that some revision in the law should be made which will make it possible for healthy, intelligent individuals to come into the country in greater numbers, and suggested a commission to be appointed by the President to inquire into the adequacy of the labor supply and the best remedy for the existing shortage.

One simple measure of relief is the postponement of public work. During times of great business activity, the government should not be bidding against the industries which form the backbone of the nation's prosperity. Generally speaking, government work is not as exacting nor as efficiently done as private work, the rates of pay are higher, hours are shorter, and the results that must be produced are easier of attainment in public than in private work. Again, the postponement of public work during times of national prosperity will insure economies in such work that cannot be obtained if the construction is done during times of abnormally good business. Another relief measure that is receiving strong support is the stoppage of many large private building and construction enterprises. This will release men to other industries, keep down construction costs, and incidentally have its effect on wage rates and living cost.

Another answer may be found in increased production per man through better machinery, and a decrease in the demand for unskilled labor through the reduction of manual handling operations. Referring to the increase in size and pressure of boiler units, he said that the manufacture of larger units is comparatively simple. We follow generally the same designs that have proved satisfactory in the smaller units, but must bear in mind that the smaller plants containing large units are not always as flexible as the older type of plant made up of a number of smaller units, and that the idle investment, when one unit is down for any reason, is greater than heretofore. Improved methods of burning greater quantities of fuel per foot of furnace width have been developed, resulting in operation at higher rates. The high pressure of yesterday is considered medium or low pressure today, and above all else a steam boiler must be safe. Powdered coal has introduced a new field of trouble for the boiler manufacturer, and its use is spreading like wildfire. Some go so far as to say that powdered-fuel installations will outnumber stoker plants in the future. He felt that this was improbable, but the facts are that two stoker manufacturers are now selling powdered-fuel equipment, and several others are seriously considering doing so. Undoubtedly, powdered fuel applied to steam boilers, to some considerable extent at least, is here to stay.

Following the president's remarks the association listened to an address by Homer D. Sayre, commissioner of the National Metal Trades Association, which, with the appointment of committees and the reports of administrative committees, completed the morning session.

In the evening moving pictures, taken especially for presentation to the American Boiler Manufacturers Association by the Bethlehem Steel Co., were shown, illustrating the manufacture of plate, flanged and dished heads, charcoal iron and lapwelded boiler tubes, and staybolt iron. This was followed by an informal round-table discussion upon practices and conditions existing in the industry.

On Tuesday morning Secretary H. N. Covell reported for the Membership Committee, E. R. Fish upon the A.S.M.E. Boiler Code and the activities of the American Uniform Boiler-Law Society.

F. C. Burton, for the Committee on Ethics, submitted a tentative code which will be presented to the member companies for consideration before final adoption.

W. C. Connelly presented, on behalf of the Commercial Committee, a special report on standardized rating of steam boilers, which recommended that boilers be sold by heating surface rather than by horsepower, but that they should be

rated upon 10 sq.ft. of heating surface per boiler horsepower. In measuring the heating surface the rules adopted tentatively by the Committee on Boiler Test Codes of the American Society of Mechanical Engineers were followed, prescribing that the surface be measured upon the side that was in contact with hot gases, that it should not include the superheater surface nor the surface in portions of the boiler which were not included in the circulation and which therefore were to be considered integral heaters or economizers.

A. G. Pratt, of the Joint Committee with the Stoker Manufacturers Association, submitted a special report upon simplified methods of determining stack sizes for both hand-fired and stoker-fired boilers. The committee had agreed "that the draft over the fire" should be taken as follows: On horizontal water-tube boilers, midway between the heating surface of the boiler and the grate surface of the stoker; on vertical and semi-vertical water-tube boilers at a point midway between the inside face of the front wall and the front face of the bridge wall, on a line with the top of the bridge wall, and that the draft at this point is not to be less than 0.15 in. suction. The committee had discussed the forms of data sheets exchanged between the boiler and stoker manufacturers, and the consensus of opinion appeared to be that the data sheets are helpful and should be continued in their present form. The question of rating boilers upon a square-foot basis was discussed, and it was recommended by the meeting that such rating, rather than a horsepower rating, be used by all boiler manufacturers, with the qualification, however, that there could be no objection to the boiler manufacturers also stating the rated horsepower, which should be based upon 10 sq.ft. of heating surface per horsepower.

Stack Dimensions Discussed

The subject of stack diameters and heights had been referred to a subcommittee consisting of E. C. Fisher, S. H. Barnum, R. L. Beers and A. H. Blackburn, and a very thorough engineering discussion of the subject, from the pen of Mr. Fisher, was presented in Mr. Fisher's absence by Mr. Barnum.

After a careful comparison of the results obtained by plotting, the results obtained from the formula of A. L. Menzin, in a paper, "Proportioning Chimneys on a Gas Basis," presented to the American Society of Mechanical Engineers at the annual meeting in December, 1915, and the formula evolved by R. A. Foresman, chief engineer of the Stoker Department of the Westinghouse Electric & Manufacturing Co., printed in *Power* of Nov. 21, 1922, it was found that the differences were so slight as to be easily accounted for by comparing the different assumptions used. It was therefore decided to adopt Mr. Foresman's curves, with the exception that the tables for chimney sizes at 100 per cent capacity were thought by some of the members to give too small a result and not to allow for the greater capacity required to make up a loss of pressure.

A vote of thanks was tendered to the committee for its thorough treatment of the subject, and the sympathy of the association extended to Mr. Fisher, who was prevented by illness from being present.

In the absence of L. E. Connelly, George W. Bach presented the report of the Conference Committee with the Smoke Prevention Association, with especial reference to the uniform setting heights of horizontal return tubular boilers. As a result of the discussion Mr. Bach was appointed a delegate of the association to attend the meeting of the Smoke Prevention Association at Minneapolis June 19 to 22.

W. A. Drake reported for the Committee on Steel Heating Boilers.

The association listened to addresses by Joseph F. Scott, president, and C. O. Myers, secretary-treasurer, of the National Board of Boiler and Pressure-Vessel Inspectors, from which it appeared that the National Board has got upon its feet, is now self-supporting and a going concern. Mr. Scott was especially strong in his condemnation of the practices of dealers in second-hand boilers. Mr. Myers told of the reorganization in Ohio and said that at the annual meeting in June of last year, 503 boilers had been registered by eighteen concerns. At the time of the mid-winter meeting in February 2,664 boilers had been registered by twenty-six concerns, and now, four months later, 6,387 boilers have been registered by thirty-five concerns. The following states and cities will accept boilers stamped with the National Board stamp without question: Rhode Island, New York, New Jersey, Maryland, Ohio, Indian, Pennsylvania, Wisconsin, Minnesota, Oklahoma, Oregon, California, Utah. Arkansas, Chicago, St. Louis, Nashville, Seattle, Parkersburg, W. Va., Kansas City, Mo.

Charles E. Gorton, chairman of the Administrative Council of the American Uniform Boiler-Law Society, reviewed the details of the work of that society during the past year. Its efforts have been directed toward consolidating the gains that have been made rather than seeking the adoption of boiler-inspection laws by other states, and in maintaining uniformity by heading off tendencies of department chiefs to adopt special rules and otherwise depart from the standard.

Wednesday morning was largely devoted to the discussion of the report of the Cost Accounting Committee, G. S. Barnum, chairman. The election of officers resulted in the choice of E. R. Fish, of the Heine Boiler Co., as president; E. C. Fisher, of the Wickes Boiler Co., vice-president; and the re-election of H. N. Covell, of the Lidgerwood Manufacturing Co., as secretary and treasurer. The new Executive Committee consists of George W. Bach, of the Union Iron Works, Erie, Pa.; G. S. Barnum, of the Bigelow Co., New Haven, Conn.; F. G. Cox, of the Edge Moor Iron Co., Edge Moor, Del.; W. C. Connelly, of the D. Connelly Boiler Co., Cleveland, Ohio; W. A. Drake, of the Brownell Co., Dayton, Ohio; A. R. Goldie, of the Goldie-McCulloch Co., Galt, Ont., Canada; J. F. Johnson; M. F. Moore, of the Kewanee Boiler Works, Kewanee, Ill.; and A. G. Pratt, of the Babcock & Wilcox Co., New York.

The usual golf tournaments were played, and the winners of prizes were announced at a banquet on Tuesday evening.

Stoker Manufacturers Meet at Lake Placid

The Stoker Manufacturers Association held its annual meeting at the Lake Placid Club, Essex Co., New York, from May 29-31. S. A. Armstrong, the president, spoke of the benefits that must accrue to the association from the facts given by papers on stokers that were presented at the Fuel Section of the A.S.M.E. during last December; of the report of the Research Committee contained in Bulletin No. 170; of the Cost Accounting Committee, which is preparing plans leading to a uniform accounting system, and he recommended the addition of a new standing committee on Industrial Relations, which would permit of study tending to the promoting of friendly relations and mutual confidence between employer and employee.

O. Junggren, consulting engineer, of the General Electric Co., presented a paper on "Development in Power Production and the Effect on Auxiliary Apparatus," which sketched the innovations that are being embodied in some of the power plants now under construction and main units and auxiliary apparatus. Among the subjects discussed were higher steam pressures and temperatures, reheating, bleeding for heating feed water, materials for turbines, surface air coolers for generators, the use of motor-driven auxiliaries, etc.

Charles G. Smoot, of the Engineering Corp., New York, gave a paper on the "Application of Automatic Combustion Control to Mechanical Stokers." There were reports from the Engineering Committee, John Van Bunt, chairman; A.S.M.E. Conference Committee, on "Care of Boilers," L. R. Stowe, chairman; Fan Committee, F. H. Daniels, chairman. A report of the Joint Committee of the American Boiler Manufacturers and the Stoker Manufacturers Association, A. H. Blackburn, chairman, considered "Stack Diameters and Heights."

The need for more rational, more practical formulas for determinging the size of chimneys for steam boilers has for some time been recognized. The real need, however, has recently been forcefully brought to the attention of boiler and stoker manufacturers because of the high ratings now being demanded. These high ratings are accompanied with high draft loss through the boilers, due to increased volumes —hence velocity—of the gases, which in turn greatly in-

MEMBERS AND GUESTS AT STOKER CONVENTION

crease friction. This loss has naturally rendered present chimney tables obsolete.

The Joint Committee met and made a study of the problem. They realized that proportioning chimneys and breechings from grate area was illogical, and that the rational method was to work from a gas basis where volume and velocity are taken into consideration. There was considered in this study the paper of Mr. A. L. Menzin, entitled "Proportioning Chimneys on a Gas Basis," presented before the American Society of Mechanical Engineers at the annual meeting in December, 1915, and to be found in the "Transactions," Vol. 23, page 1065. The committee recommends the reading and study of that paper because the theory there used is very clearly and simply set forth.

The Committee recommended that the square-foot basis for rating boilers be adopted.

The Statistical Committee submitted two charts, one of which stated the number and capacities of stokers and boilers sold covering the period from January, 1919, to April, 1923.

The new executive committee is as follows: President, J. C. Worker; vice-president, J. V. Santry; treasurer, R. B. Mildon; and F. H. Daniels and W. H. Rea.

Indiana N. A. S. E. State Convention

On May 28 and 29 the Indiana State Convention of the National Association of Stationary Engineers was held at Purdue University, Lafayette. With the assistance of the mechanical engineering staff of the university an excellent program had been prepared and was appreciated by an attendance approximating 200. The various sessions were held in the Mechanical Engineering Building, and in the laboratory of the same building space was available for some thirty exhibitors' displays. Test work in process was an added attraction, operation of the new Prosser engine, which has been under test for some time, being watched with interest.

At the opening session Monday the engineers were welcomed to the university by the president, Dr. Edward C. Elliott, and to the city by M. W. Miller, chief of the waterworks. The responses in behalf of the association were made by F. L. Clifford and H. V. Wallace, president and secretary, respectively.

Dean A. A. Potter, addressing the afternoon session, pointed out the importance of the engineer in present-day progress and reviewed briefly the training of the students the state. T. A. Marsh gave an instructive talk on powdered coal, bringing out the features of design and operation, with data on efficiencies obtained, furnace volume and cost of preparation. Morse Dellplain, of the Northern Indiana Gas & Electric Co., stated that the central station was vitally interested in the association as it helped to develop good engineers. The time for enmity was past. Owing to its great development the central station offered a wonderful field. It had increased rather than diminished the opportunity of the engineer.

At the Tuesday sessions six papers were presented. W. Seigerist reviewed Heine boiler construction from the early days to the present time, bringing out in detail the late designs and ending up with a reel showing the boilers under construction.

James E. Lea, of the Lea Recorder Co., Ltd., Manchester, England, was present and was given the opportunity to explain the action of his new volume coal meter designed to integrate continuously the coal fed to chain-grate stokers. With the width of the fuel bed constant, two variables remain to be taken into account by the meter. These are the depth of the fuel bed, measured under the gate, and the speed of travel. The measurement of the coal stream is made in cubic feet, but the transfer to pounds, if desired, is simplified by the fact that the weights of equal volumes of the same coal of different sizes are practically identical. This rather surprising point was demonstrated by the speaker. A distinct advantage of volume measurement is the elimination of error due to moisture.

H. W. Cross, of the General Electric Co., gave some interesting details on steam turbines of the extraction type. Prof. J. W. Keller demonstrated to the audience why steel warps and explained how shafts might be straightened by the application of heat.

Prof. S. W. Parr, from the University of Illinois, emphasized the importance of coal storage and the advantages to the miner and the railway of uniform production. As to the two disadvantages, danger of fire and loss in heat value, the former could be avoided by storing coal of definite size and not mixtures of fine and coarse. Professor Parr made the astonishing statement that the apparent average loss of 2½ per cent in heat value from storage does not exist if the increase in weight of the coal from the absorption of oxygen is taken into account. Stored coal, however, shows less life and does not ignite so readily as fresh coal. The reason remains to be discovered. Prof. H. C. Peffer gave an elementary discussion on lubrication, enumerating the qualities that a good lubricant shou'd possess.

Of the business routine the License Committee reported no activity as they did not wish to interfere with the new boiler code measure that had been introduced but failed to pass. The convention voted the appointment of a new committee and requested that a bill be prepared for presentation to the next legislature. A resolution calling upon the national body to convene every two years instead of annually, in order that the money saved in mileage might be devoted to educational purposes, was voted down.

A close vote on the next convention city resulted in favor of Lafayette, over Fort Wayne. Following are the officers elected for the coming year: H. V. Wallace, president; A. J. Cassel, vice-president; Prof. A. W. Cole, secretary; E. G. Heeger, treasurer; Harry Cooper, conductor; Howard Gluys, doorkeeper; H. C. Carroll, state deputy.

The practical man who is well grounded in the principles of combustion, will be able to make an intelligent study of his own plant and to find out and remedy whatever is wrong. The result will be a reduced coal bill, and increased satisfaction.

News in the Field of Power

Accident to Hydraulic Turbine at Shawinigan

In the latter part of May there occurred a serious accident to the 41,000-hp. hydraulic turbine at the plant of the Shawinigan Water & Power Co. at Shawinigan Falls, Quebec, Canada. The exact cause of the accident has not been definitely settled as there has been very high water and access to the draft tube and inspection has not been possible.

According to officials of the company, about two weeks ago there was a log jam in front of the trash rack that was so extensive that it almost cut the water off the turbine. This débris was removed and subsequent examination of the rack did not disclose any apparent damage such as might permit of the passing of logs or parts of logs through it. Later, however, two blades of the runner were broken, in some manner, and the broken parts, in being carried around, closed the gates by breaking the shear links in the governor control and shutting off the water. The generator and other parts appeared undamaged. Dismantling has been postponed until the water gets lower and until replacement parts can be received.

Freight Transportation Waste Conference To Be Held

Reduction of waste in freight transportation will be considered at a conference on June 13 at the Department of Commerce. F. R. Wadleigh, who is making the arrangements for the conference, states that he believes savings that will run into huge sums can be made if more attention is given to prompt loading and unloading of freight cars; to the securing of a higher average day's mileage; to the loading of cars to capacity, and to a large number of opportunities which are offered shippers and transportation companies to eliminate waste.

Encyclopedia of Standards and Specifications To Be Issued

Specifications and standards to apply to all commodities moving in interstate or foreign commerce were discussed at a conference held at the Department of Commerce on June 11. F. R. Wadleigh was in charge of the arrangements for the conference. Mr. Wadleigh is planning the issuance of an encyclopedia of specifications and standards. He believes it is possible to apply to most commodities the same principle that is working out so well in the simplifications and standards for the commodities purchased by the government.

New Jersey Stationary Engineers Hold Convention

At the thirty-second annual convention of the New Jersey State Association of Stationary Engineers, held at Trenton, June 1-3, there were about 200 delegates from the various cities of the state and a large attendance of the Ladies Auxiliary. John J. Reddy, state deputy, called the opening session of the convention to order at ten o'clock and told of the healthy condition of the organization and the evident increase in the membership among the local sections. John Mycock, the state president, welcomed the delegates and visitors and referred with pride to the high standing of the N.A.S.E. in New Jersey. National President Fred Felderman made an earnest appeal to the members to take advantage of the great educational features offered by the association. Past National President John J. Callahan spoke of the members who had passed away during the last year, and William J. Reynolds told of the unveiling of the monument on Memorial Day at Fairmont Cemetery, Newark, N. J., to the memory of the first national president, Harry E. Cozens.

Moose hall and the auditorium in the same building, tastefully decorated, held the mechanical products exhibit among which were many new developments. About sixty firms were represented in the display which was well patronized during the convention.

William Sitzler was elected president for the ensuing year, Samuel Clark, vice-president, Joseph Flynn, secretary, and H. W. Vail, treasurer. Newark, N. J., will be the meeting place for the next convention.

Interpretation of the New York Engineers License Law

Some Confusion Has Existed in Regard to the Application of This New Licensing Law

THE New York Engineers License law will take effect Aug. 1, 1923, and every engineer who has not applied for a license and whose work is such as to require a professional engineer's license, is urged to make application without delay, as the law may be interpreted to apply to everybody doing engineering work which may be deemed "responsible," or any person not licensed on or before May 1, 1923 (later changed to Aug. 1, 1923) who publicly calls himself an engineer is liable, upon trial and conviction, to fine or imprisonment or both.

The American Institute of Electrical Engineers has had a committee at work upon this legislation and it has prepared the following statement of its understanding of this law:

An engineer who has (or offers from an office in the state to take) charge of engineering work for a client, or as a salaried employee, must be licensed if this work involves "the planning, designing, construction, inspection, and supervising of engineering work, or appliances involved in public or private projects, or in making investigations for proposed engineering projects."

The technical head of the engineering department of any manufacturer of "appliances involved in public or private projects" and the engineer who "supervises" the operation of the engineering branch of a public utility, must be licensed just as much as the engineer engaged in consulting practise. If the principal engineer has a deputy who has full responsible charge in the principal's absence, the deputy must be licensed. An operating engineer of a power plant holding an operating engineer's license issued under other laws of the state does not have to be licensed under the professional engineer licensing law in order to continue his engagement as an operating engineer.[1]

An engineer who neither resides nor has an office in New York State may, without taking out a New York license, offer to do engineering work in the state and actually do such work there for not more than thirty days in a calendar year if he is legally qualified as an engineer in his own state.

If a manufacturer sells a product which his men erect in the field by methods not involving engineering skill and knowledge, the erectors need not be licensed. But if the manufacturer furnishes in addition to his own products, plans for structures not made in his shops and calling for more than the ordinary skill of a skilled workman to execute, such plans must be made by a licensed engineer and the field work must be supervised by a licensed engineer.

Salesmen employed by manufacturers, who give advice to customers on "planning, construction, inspecting and supervising of engineering work or appliances" other than those produced by

[1]Sec. 39-n of the Engineers' License Laws—Professional Engineering: A person practices professional engineering within the meaning and intent of this article, except as hereinafter stated, who holds himself out as able to do, or who does, the work that an engineer does in the planning, designing, constructing, inspecting and supervising of engineering work, or appliances, involved in public or private projects or in making investigations for proposed engineering projects.

the manufacturer, must be licensed as professional engineers.

Engineers employed in "service departments" or "trouble departments" of manufacturers of "appliances," who must give advice about other engineering matters than those "appliances" in order that the latter may function satisfactorily, must probably be licensed. It is often difficult to fix the place where skilled craftsmanship ends and professional engineering begins, in the work of these men.

Engineers who may be called into court to testify as engineers, will doubtless find the possession of a license helpful in qualifying even though they are not compelled by law to be licensed.

This license will cost the applicant $25, to be sent with the application, and one dollar annual renewal fee. For detailed information, license forms, etc., apply to Herbert J. Hamilton, Asst. in Charge of Professional Examinations, State Education Bldg., Albany, N. Y.

Fatal Boiler Accident in Detroit

On Saturday, June 2, when two men were cleaning a boiler at the Detroit plant of the Continental Motors Corporation, steam was turned into the boiler and the men were instantly killed.

While complete details of the accident will not be made public until the conclusion of an investigation by the Commissioner of Public Safety, it is understood that immediately following the Saturday shutdown at the plant, the blowoff of an adjoining boiler was opened into a common blowoff line, thus permitting steam to fill the boiler being cleaned. The responsibility for the accident had not been fixed, it was said at the plant Saturday night.

New England Power Situation To Be Investigated

President Gow, of the Associated Industries of Massachusetts, in accordance with the unanimous vote of the executive committee, has appointed a committee to make an investigation of the power situation of New England. The following gentlemen have been asked to serve on the committee and all have accepted: Charles T. Main, past president of the A.S.M.E. is to be chairman, and the other members are Henry I. Harrison, of the New England Power Co., Boston; Prof. Dugald C. Jackson, of the Massachusetts Institute of Technology, Cambridge; George L. Finch, Hood Rubber Co., Watertown, and B. Preston Clark, Plymouth Cordage Co., North Plymouth.

Indianapolis A.S.M.E. To Work for Smoke Prevention

The Smoke Prevention Committee of the Indianapolis Section of The American Society of Mechanical Engineers has prepared a smoke-abatement ordinance to be presented to the city council. The smoke problem in Indianapolis is a serious one. The A.S.M. E. local section there has helped to wage an educational campaign on the economic aspects of smoke abatement. Public sentiment has been aroused, and various civic organizations are standing back of the smoke-abatement ordinance which the special Committee of the A.S.M.E. has drawn up and which is provided with sufficient "tooth," to make it effective.

Ford Company Will Use Largest A-C Motor in Steel Mill

The largest alternating-current motor for steel mill use ever made in this country is being designed by the General Electric Co. for use at the River Rouge plant of the Ford Motor Co. at Detroit, Mich.

This motor will develop 8,000 hp. with a speed of 240 r.p.m. It will be used to drive a large "blooming" mill at the River Rouge plant, where installations are now being made to manufacture steel. High-grade alloy steel will be the principal product of the plant for the present. The plant will be equipped with a "merchant" mill, for which the General Electric Co. is making a 4,500-hp. direct-current motor. Power will be supplied by four 2,000-kw. motor-generator sets.

Coal Commission To Have Constructive Suggestions

The President's Coal Commission is confident that it is to receive constructive suggestions from both coal miners and operators whether they are through throwing mud at each other or not. Chairman Hammond described as "constructive" a statement submitted by the railroads and reiterated his former statement that the commission will recommend a reduction in the freight rate of anthracite, but warned that it would be a long time before it could be put into effect, and expressed the hope that the public would not delay the purchase of coal on the prospect of benefiting from the rate reduction. Dr. Smith recalled how those who waited for reduction when the bituminous rate was under consideration were penalized.

Coffin Medal Presented to Southern California Edison Co.

The Southern California Edison Co., Los Angeles, was presented with the Charles A. Coffin Foundation gold medal on June 7, at the meeting of the Public Policy Committee of the National Electric Light Association during its annual convention in New York City.

This is the first award of the medal made by the Foundation, which was created by the General Electric Co., and was awarded for the most notable contribution to the development of electric-light and power service during the year. Frank W. Smith, president of the N.E.L.A., officially presented the medal, and John B. Miller, president of the Southern Edison Co., accepted it.

New Publications

Engineering Index, 1922. Published by the American Society of Mechanical Engineers, 29 West 39th St., New York City. Cloth; 9¼x6¾ in.; 675 pages. Price, $6.

The Index for 1922 is the largest and the most concise of the yearly engineering indexes that has been published so far by the American Society of Mechanical Engineers. It contains engineering references from 1,300 of the leading engineering periodicals and reports of every country. Arrangements can be made in connection with the Index, for photostatic copies of drawings or pages from any article noted in it. For ready reference this book is invaluable. It is to be regretted that the magazines are not analyzed more closely, even at the expense of increase in size and cost.

Practical Heat. Edited by Terrell Croft, assisted by staff of contributors. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave, New York City, 1923. Cloth; 5½x8 in.; 695 pages, 628 illustrations. Price, $5.

The reader of "Practical Heat" needs no preparation except good mechanical sense and a knowledge of ordinary arithmetic. Starting with the simplest concepts he is led step by step to an understanding of each principle and then, without delay, to its practical application. Each step is thoroughly explained and illustrated by examples and pictures. Each practical application is clinched by the solution of problems. The first section of the book explains in great detail the fundamental ideas of force, pressure, work, energy and power giving numerous applications. Then come matter, heat, temperature and the sources of heat. With this foundation the reader is well prepared for the chapters on heat measurement and transformations, transfer of heat and the effects of heat. Succeeding chapters cover the expansion of solids and gases. Under the heading of vaporization many applications are explained, including cooling ponds and towers, condensers, steam generation and humidity calculations. The chapter on steam and other vapors explains the meaning of steam-table data and shows the practical applications of total heat, entropy etc. Succeeding chapters treat of gas and vapor cycles, fuels and combustion. This concludes the first half of the book, which builds a foundation for the more direct treatment of the applications in the second half. This portion of the book devotes over two hundred pages to a study of steam power plants, internal-combustion engines, building warming, refrigeration and instruments. The engineer who completes the study of this book will not only ground himself in the fundamentals of heat but will also learn how to apply this knowledge directly to the solution of the practical problems of every-day engineering.

Society Affairs

The Engineer's Society of Pennsylvania have installed new officers as follows: President, R. W. Moorhead; First vice-president R. L. Gillispie; second vice-president, Charles Haydock; directors, John McIlhenny Smith, George W. L. Cullen, Richard C. Newbold; secretary, Howard E. Moses; treasurer, P. E. Fickenscher.

The Engineering Section of the National Safety Council will hold its second annual meeting at Detroit, Mich., in co-operation with the Detroit Safety Council on June 12. Arthur H. Young, former president of the Council, will speak on "Safety Work that Pays Dividends," and Judge Alva R. Corlett, Cleveland traffic court magistrate, will tell of his experience in preventing street accidents by law enforcement.

Personal Mention

Carl P. Hubbard, formerly supervising engineer at Chicago for Lockwood, Greene & Co., has become associated with Stone & Webster, Inc., of Boston, at their Chicago office.

David Brownlie, 46 Grange Road, Ealing, London, W. 5, has by amicable arrangement severed his connection entirely with Messrs. Brownlie & Green, Ltd., of Manchester and London, and is now engaged in private practice as an advisory specialist in all matters relating to fuel economy in the wide sense of the word, particularly the carbonization of coal and coal saving by improved methods of steam generation, scientific control of boiler plant, either in connection with existing or new plant, the use of back pressure or pass-out steam, black smoke and feed-water troubles. Mr. Brownlie is acting throughout in a purely personal capacity without staff other than clerical and announces that he will still continue with his literary activities.

Business Notes

The **General Electric Co.** announces that H. R. Sargent, formerly manager of the wiring supplies division of the Bridgeport works, has been appointed managing engineer of this division under a development plan that will create several unit divisions.

Uehling Instrument Co., Paterson, N. J., has just made two agency appointments; The Amsler-Morton Co., Fulton Building, Pittsburgh, Pa., for western Pennsylvania, and John A. McDowell, 2039 Railway Exchange Building, St. Louis, Mo., for eastern Missouri and southern Illinois. H. R. N. Johnson, former representative of the company in Minnesota and the Dakotas, has joined the W. P. Nevins Co., 120 South Main St., Minneapolis, Minn., and this company will now be the official representative for that territory.

Coming Conventions

American Institute of Chemical Engineers; Dr. J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Convention at Wilmington, Del., June 20-23.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Summer Convention at Swampscott, Mass., June 25-29.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Penn. Annual meeting at Atlantic City, N. J., June 25-30.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th Annual Convention at Toronto, Canada, June 25-28.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Michigan** at Flint, July 18-20. E. C. Smith, 308 Vine St., Kalamazoo, Mich. **New England States Association**, at Manchester, N. H., Manchester hotel, July 12-14; Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Iowa**, at Mason City, Iowa, June 11-14; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa. **Ohio**, at Dayton, June 21-23; J. H. Weaver, 22 N. Gift St., Columbus, Ohio. **Pennsylvania**, at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York**, at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota**, at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Ave. N. E., Minneapolis. **Connecticut**, at Waterbury, June 29-30; L. Van Der Eyk, 251 Wood St., Waterbury.

National District Heating Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

The New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

Ohio Electric Light Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, July 10-13.

Smoke Prevention Association; Frank Chambers, 111 N. Dearborn St., Chicago, Ill. Convention at Minneapolis, Minn., June 19-22.

Society for the Promotion of Engineering Education; F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. Annual meeting at Cornell University, Ithaca, N. Y., June 20-23.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Rochester, N. Y., Aug. 7-11.

Trade Catalogs

The **Link-Belt Co.**, 910 South Michigan Ave., Chicago, announces that L. M. Dalton has succeeded E. J. Burnell as manager of the Boston branch office.

B. F. Sturtevant Co., of Hyde Park, Boston, Mass., has purchased the plant of the Wisconsin Engine Co., at Corliss, Wis., maker of Corliss pumping engines, and has appointed Harry W. Page as general manager.

Oil Burning Equipment, Quinn—Combustion Engineering Corp., 43-47 Broad St., New York City. Catalog QC-1, "A Complete Treatise on the Subject of Oil Burning," gives pictures and descriptions of fuel oil burning equipment and installations.

Oil-Burning Accessories—G. E. Witt Co., 862 Howard St., San Francisco, Calif. Catalog No. 10 gives the descriptions, useful tables of sizes, illustrations and instructions for ordering its pressure regulating valves for all purposes, and oil-burning equipment. A good index is included in this catalog.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	May 28, 1923	June 4, 1923
Pool 1,	New York	$3.75	$3.50@4.00
Smokeless,	Columbus	4.15	4.00@4.50
Clearfield,	Boston	2.35	2.00@2.75
Somerset,	Boston	2.60	2.50@3.25
Kanawha,	Columbus	2.05	1.90@2.20
Hocking,	Columbus	1.90	1.75@2.00
Pittsburgh No. 8	Cleveland	2.25	2.15@2.25
Franklin, Ill.	Chicago	3.10	3.00@3.25
Central, Ill.	Chicago	2.10	2.00@2.25
Ind. 4th Vein,	Chicago	2.85	2.50@2.75
West Ky.,	Louisville	1.80	1.75@1.85
S. E. Ky.,	Louisville	2.25	2.00@2.50
Big Seam,	Birmingham	2.05	1.85@2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—June 7, Port Arthur light oil, 22@25 deg. Baumé, 5⅝c. per gal.; 30@35 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—May 26, 24@26 deg. Baumé, $1.97 per bbl.; 32@36 deg., $2.27 per bbl. tank cars.

Philadelphia—May 14, 26@28 deg. Baumé. Oklahoma, $1.10@$1.15 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3¾c. per gal.; 16@20 deg. Seaboard, $1.75@$1.90 per bbl.

St. Louis—May 29, tank-car lots, f.o.b. St. Louis; 24@26 deg. $1.80 per bbl., 26@28 deg., $1.85 per bbl.; 28@30 deg., $1.90 per bbl.; 32@36 deg., gas oil, $2.15 per bbl.; 36@40 deg., distillate $2.35 per bbl.

Pittsburgh—June 5, f.o.b. local refinery, 30@34 deg., fuel oil, 4⅞c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 8¼c. per gal.

Dallas—June 2, f.o.b. local refinery 26@30 deg., $1.57 per bbl.

New Plant Construction

PROPOSED WORK

Calif., Glendale—The Crescent Creamery Co., 237 Winston Ave., Los Angeles, is having plans prepared for the construction of a creamery, including a 2 story, 95 x 190 ft. main building and a 95 x 150 ft. boiler house, here. Cost will exceed $75,000. Morgan, Walls & Morgan, Van Nuys Bldg., Los Angeles, archts.

Calif., Los Angeles—The Court Drug Co., 860 South Hill St., plans to build a 12 story store and office building on Grand Ave. and 12th St. Cost will exceed $750,000.

Calif., Los Angeles—Macdonald & Kahn and A. C. Blumenthal, Loew State Bldg., will build an 8 story apartment hotel on 7th St. near Valencia St. Estimated cost $300,000. Equipment detail not reported.

Calif., Los Angeles—C. E. Page is having plans prepared for the construction of a 12 story, 95 x 114 ft. office building on 6th St. and Grand Ave. Estimated cost $850,000. Milwaukee Bldg., Co., Wright-Callender Bldg., Los Angeles, Archts.

Calif., San Francisco—A. Abrams, 2151 Sacramento St., rejected bids and will have revised plans prepared for the construction of a 10 story hospital on Sutter St. near Larkin St. Estimated cost $300,000. M. I. Schwartz, Nevada Bank Bldg., San Francisco, Archt. Noted Apr. 10.

Calif., San Francisco—The Mt. Zion Hospital, Post and Scott Sts., is having plans prepared for the construction of a 6 story nurses' home, including roof garden and auditorium, on Sutter St. between Scott and Divisadero Sts. Estimated cost $500,000. S. Schnaittacher, 233 Post St., San Francisco, Archt. Equipment detail not reported.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., has had plans prepared for the construction of a pump house, including installation of 48 in. diameter conduit, 275 ft. long, one concrete intake on one end and pump house on the other end; two 18 in. pumps, capacity 7,000 g.p.m.; miscellaneous discharge pipes, 2 story pump house with sump traveling refuse screens on 1st floor and switch department, intake and stationary refuse screens on 2nd floor. Estimated cost $110,000. Private plans.

Calif., San Jose—The County of Santa Clara, H. A. Pfister, Clk., will receive bids until July 2 for furnishing and installing refrigerating and ice making plant, also for construction of building to house same, at the county hospital grounds. Noted June 5.

Colo., Denver—The Capital Life Insurance Co., Colorado Theatre Bldg., is having plans prepared and will receive bids in about two months for the construction of a 2 story, 160 x 250 ft. office building on Sherman St. and 16th Ave. Estimated cost $600,000. H. J. Manning, Majestic Bldg., Denver, Archt.

Conn., New Haven—C. Roessler, 60 Pearl St., is having plans prepared for the construction of a 2 story, 20 x 60 ft. and 30 x 80 ft. garage and factory for the manufacture of bologna, including steam heating system, on State St. Estimated cost $60,000. R. W. Fabian, 147 Bradley St., New Haven, Archt. The owner is in the market for refrigerating machinery.

D. C., Wash.—The Bureau of Yards & Docks, Navy Dept., L. E. Gregory, Cn. of Bureau, will receive bids until June 20 for auxiliary equipment and piping in connection with Diesel-engine-driven alternator sets, now being installed under another contract, including installation of lubricating and oil, supply pumps and motors, oil coolers, oil sump tanks, air starting flasks, circulating water pumps, all of which will be furnished by the Government; provision and installation of a gasoline driven air compressor, motors for the circulating water pumps, exhaust heater, c.i. radiators, foam fire extinguisher, oil storage and supply tanks, concrete pipe trench and valve chamber, wiring to the motors, all accessories and complete piping systems for all equipment in the power house at the Navy Mine Depot, Yorktown, Va.

D. C., Wash.—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., will receive bids until June 28 for the installation complete of two oil operated mail lifts with pumping plant for the United States Post Office and Court House, Detroit, Mich.

Fla., Bradentown—I. T. Roberts & Associates, Birmingham, Ala., are having plans prepared for the construction of a 6 and 8 story, hotel on Manatee River. Estimated cost $2,000,000. M. L. Elliott, Citizens Bk. Bldg., Tampa, Fla. Equipment detail not reported.

Ga., Alto—The State Bd. of Health, State Capital, Atlanta, is having plans prepared for the construction of a sanitarium for the treatment of tubercular patients, in the Blue Ridge mountains, near here. Estimated cost $500,000. Daniele & Bentell, Healy Bldg., Atlanta, Archts. Equipment detail not reported.

Ill., Chicago — Hillman's Department Store, 20 North State St., plans to build a 16 story department store, including steam heating system, at 18 North State St. Estimated cost $3,000,000. Engineer or architect not selected.

Ill., Chicago—Kurt, Rosenthal & Co., 11 South La Salle St., are having plans prepared for the construction of a 3 story, 165 x 172 ft. apartment hotel, including steam heating system, on Lunt and Greenview Sts. Estimated cost $250,000. S. W. Eichberg, 64 West Randolph St., Archt.

Ill., Freeport — The Methodist Hospital Assn., A. Van Nuys Secy., plans to build a 4 story hospital to contain 100 beds, including steam heating system. Estimated cost $300,000. Architect will be selected by competition.

Ill., Savanna—The Carroll County Drainage & Levee Dist. No. 8, H. P. Greison, Secy., will receive bids until June 26 for an oil engine driven pumping plant containing a 30 in. double suction centrifugal pump, also for construction of pump house. Elliott & Harman Eng. Co., 144 Fredonia St., Peoria, Engrs.

Ind., Anderson—The Boland & Hoard Ice Cream Co. is in the market for additional refrigerating equipment.

Ind., Kendallville—The city is having plans prepared for the construction of an addition to its electric light and water works plant. Estimated cost $40,000. H. H. Mortoroff, engr.

Ky., Louisville—J. G. Brown, c/o Brown Lumber Co., 1522 6th St., plans to build a 10 story annex, to contain 300 rooms, to hotel on Broadway. Estimated cost $1,000,000.

Ky., Louisville—St. Joseph's Infirmary, 4th St., is having plans prepared for the construction of a 6 story infirmary on Eastern Parkway between Preston and Floyd Sts. Estimated cost $1,500,000. D. X. Murphy & Bro., 714 Louisville Trust Bldg., Louisville, Archts. Equipment detail not reported.

Ky., Owensboro — The Owensboro Clay Products Co. plans to build a plant and power house, for the manufacture of brick and other clay products. Estimated cost $150,000.

La., New Orleans—G. J. Glover, Genl. Contractor, Whitney Bank Bldg., is receiving bids for the construction of a 3 story building, with power house, stable, etc., for the Cloverland Dairy Co., Carrolton Ave. and Olive St. Estimated cost about $300,000. Favrot & Livaudais, Hibernia Bank Bldg., Archt.

La., New Orleans — The International Harvester Co., 606 South Michigan Ave., Chicago, Ill., have obtained a 10 year lease of 3 floors in Warehouse No. 1 of the Army Supply Unit from the Board of Port Commissioners of New Orleans and plan making extensive improvements, including the installation of a power plant and the building of railroad tracks.

Md., Baltimore—W. S. Austin, Consult. Engr., 1002 Maryland Trust Bldg., is in the market for a 150 hp. 150 lb. pressure, H. R. T. Boiler; boiler feed pump; open type feed water heater; receiving tank; boiler blow off tank.

Mass., Boston—The City, Room 504 City Hall Annex, J. A. Rourke, Comr., is having plans prepared for the construction of a 2 story, 53 x 220 ft. garage with 30 x 165 ft. ell to contain boiler room on Albany St. Estimated cost $150,000. Mulhall & Holmes, 248 Boylston St., Boston, Archt.

Mich., Grand Rapids—The Burleson Sanitarium is having sketches prepared for the construction of a 10 story, 106 x 146 ft. sanitarium and hotel on Fulton St. Estimated cost $1,000,000. Osgood & Osgood, Fine Arts Bldg., Grand Rapids, Archts.

Minn., Elbow Lake—The village will receive bids until June 15 for one centrifugal pump and motor for water department. J. E. Bonner, Sauk Center, Engr.

Minn., Minneapolis—G. R. Newell & Co., 1st Ave. N. and 3rd St., L. P. Newell, Purch. Agt., is in the market for refrigerating machinery for new warehouse, now under construction.

Miss., Louisville—The city council plans a $30,000 bond issue for the construction of a new electric light and power plant. Engineer not announced.

Mo., Holden—The city holds an election June 12 to vote $75,000 bonds for the construction of waterworks improvement, including rebuilding of present dam, new filtration plant and pumping station, also extension to water mains and laterals. Benham Eng. Co., 512 Gumble Bldg., Kansas City, Engrs. Noted Feb. 6.

Mo., St. Louis—The Bd. of Public Service, Room 208, City Hall, will receive bids for equipment for power plant, including two horizontal water tube single drum type boilers, not less than 2,200 sq.ft., active heating service and 3½ or 4 in. tubes, 16 ft. long, for the St. Louis Training School for Feeble Minded, Halls Ferry and Bellefontaine Rd. Estimated cost $25,000.

Mo., St. Louis—F. L. Cornwall, La Salle Bldg., will build a 7 story, 44 x 125 ft. apartment hotel on Lindell Blvd. and Whittier St. Estimated cost $300,000. Equipment detail not reported.

N. J., Camden—The Stanley Theatre Co., 13th and Market Sts., Phila., Pa., is having plans prepared for the construction of a 1 story, 110 x 160 ft. theatre on 6th and Market Sts., here. Estimated cost $1,000,000. Hoffman-Henon Co., Finance Bldg., Phila., Archts. Equipment detail not reported.

N. Y., Albany—The Municipal Gas Co., 126 St., plans the construction of an electrical sub-station in Partridge St. Estimated cost $25,000.

N. Y., Brooklyn—H. Wittmann, 188 Montague St., is having plans prepared for the construction of an office building on Church Ave. and East 21st St. Estimated cost $600,000. M. Klein, 37 Graham Ave., Brooklyn, Engr. and Archt. Equipment detail not reported.

N. Y., Buffalo—The Walbridge Co., 392 Main St., H. E. Bowen, interested, is having plans prepared for the construction of a 10 story, 94 x 102 ft. office building on Court St. Cost will exceed $500,000. Architect's name withheld. Noted Sept. 12.

N. Y., Charlotte—Fruit Growers' Syndicate, is in the market for cold storage machinery and equipment for $150,000 plant.

N. Y., Jamestown—The Hotel Jamestown, Inc., 3rd and Cherry Sts., will receieve bids until June 18 for the construction of a 10 story hotel. Estimated cost $1,225,000. W. L. Stoddart, 90 East 40th St., New York, Engr. and Archt. Equipment detail not reported. Noted Feb. 6.

N. Y., New York—The Northern Union Gas Co., 1815 Webster Ave., will soon receive bids for alterations and the construction of an addition to its office building. Estimated cost $800,000. Jardine, Hill & Murdock, 60 East 42nd St., New York, Engrs. and Archts. Equipment detail not reported.

N. Y., North Tonawanda—The Dealers Lumber Co., 59 Thompson St., is in the market for one 220 volt, 60 cycle, 2 phase motor.

N. Y., Norwood—The Power Corp. of New York, J. N. Carlisle, Pres., Light & Power Bldg., Watertown, will have plans and estimates prepared for hydro-electric development, including dam, power house and generating equipment on the Racquette River, here. Estimated cost $750,000. W. P. Creager, Northern New York Trust Co. Bldg., Watertown, Ch. Engr.

N. Y., Rochester—The Rochester Gas & Electric Corp., Clinton Ave., N., is in the market for power plant machinery and equipment for $90,000 transformer station of West Swan St.

Ohio, Cincinnati — The Masonic Bldg. Com. is having plans prepared for the construction of a Scottish Rite Cathedral on 5th and Sycamore Sts. Estimated cost $2,000,000. H. Hake, Telephone Bldg., Cincinnati, Archt. Equipment detail not reported.

Ohio, Cleveland—The city received bids for two 1,400 hp. boilers with superheaters from D. Connolly Boiler Co., Ivanhoe Rd., Cleveland, $84,528; Babcock & Wilcox Co., Guardian Bldg., Cleveland, $91,481. Noted May. 22.

Ohio, Orient—The Dept. of Welfare, 9th and Oak Sts., Columbus, J. E. Harper, Dir., will receive bids until June 27 for the construction of a 1 story, 48 x 115 ft. cold storage plant with refrigerating equipment at the Institution for Feeble Minded here. Estimated cost $60,000. Noted under Columbus, June 5.

Okla., Duncan—The Duncan Wholesale Grocery Co. is in the market for a 25 hp. motor for elevator.

Okla., Elk City—The Williams & Miller Gin Co. is in the market for a 500 hp. compound condensing engine.

Okla., Sayre—The city is having plans prepared for the construction of a power plant; water mains and sewer extensions; complete disposal plant; white way. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs. Noted July 12, 1921.

Okla., Tulsa—The Central Natl. Bank, 2nd and Boston Sts., is having plans prepared for the construction of a 15 story, 50 x 140 ft. bank and office building. Estimated cost $2,000,000. D. H. Burnham & Co., Rookery Bldg., Chicago, and H. H. Mahler & Co., 231 Lynch Bldg., Tulsa, Archts. Equipment detail not reported. Noted Jan. 2.

Okla., Tulsa—The city is receiving bids for two 300 hp. boilers, one 10,000,000 and one 12,000,000 gal. turbine centrifugal pump also for 4 mi. of 30 in. steel or c.i. force main pipe. Trammel & Holway, 50 Wright Bldg., Tulsa, Engrs.

Ore., Ketchum (Grass Valley P. O.)—The Pacific Power & Light Co., L. A. McArthur, Mgr., Gasco Bldg., Portland, is having surveys made from the mouth of the Deschutes River to 20 miles above, for the construction of a 40,000 hp. hydro-electric power plant. Estimated cost from $2,000,000 to $3,000,000. H. H. Schoolfield, Ch. Engr.

Pa., Nanty Glo—The Nanty Glo Business Men's Assn. and the New York Silk Mfg. Syndicate plan to build a 3 story, 80 x 140 ft. silk mill and a 1 story power plant along Blacklick river and Pennsylvania R.R. tracks. Estimated cost $150,000. Engineer or architect not announced.

Pa., Greensburg—The Fisher Traffic Co. is in the market for ice making and cold storage equipment for plant at Jeannette.

Pa., Jeannette—The Jeannette Ice & Cold Storage Co. is in the market for equipment for new ice plant.

Pa., Phila.—J. S. Ivans' Sons, Inc., 625 North Broad St., are having plans prepared and will soon receive bids for the construction of a 5 story bakery with detached power plant, including elevators, conveying equipment, boilers, engines, generators, motors and wiring at 4811 Germantown Ave. Estimated cost $600,000. W. E. S. Dyer, Land Title Bldg., Engineer and Architect.

Pa., Uniontown—The White Swan Hotel Co. is having plans prepared for the construction of a 5 story, 150 x 155 ft. hotel on West Main St. Estimated cost $500,000. Dreher & Churchman, Otis Bldg., Phila., Archts. Equipment detail not reported.

S. D., Esmond—The city, G. E. Gardner, Clk., will receive bids until June 30 for the construction of a complete waterworks system, including 3,500 ft. of 4 in. c. i. pipe; six 4 in. gate valves and boxes; nine 4 in. hydrants; 2,000 lb. c. i. fittings; one 100 to 140 gal. centrifugal pump or one 50 gal. triplex pump; 20 x 40 ft. pump house with underlying reservoir; alternate bids on steel tower, 80 or 100 ft. high, and tank, 30,000 or 50,000 gal. capacity. Estimated cost $15,000. Druar & Milinowski, 500 Globe Bldg., St. Paul, Minn., Engrs.

Tenn., Athens—The Tennessee Power Co., Ham Natl. Bank Bldg., Chattanooga, has been granted a franchise by the city for the construction and operation of an electric power plant, here.

Tenn., Memphis—The Elks Club, Jefferson St., is having tentative plans prepared for the construction of a 12 story, 75 x 148 ft. lodge, hotel, club and office building on Front and Jefferson Sts. Estimated cost $750,000. Mahan & Broadwell, Amer. Bank Bldg., Memphis, Archts.

Tex., Dallas—The Kleber Baking Co., 311-313 North Akard St., is in the market for a 25 hp. motor, starting boxes and ice making machinery.

Tex., Denison—The Denison Hotel Co., A. O. Simpson, c/o Chamber of Commerce, will receive bids about June 15 for the construction of a 6 story, 120 x 250 ft. hotel on Main St. Estimated cost $300,000. Engineer or architect not announced. Equipment detail not reported. Noted Apr. 24.

Tex., Fort Worth—The Y. M. C. A., 914 Monroe St., R. E. Squires, Secy., has had plans prepared for the construction of a 4 story, 100 x 145 ft. Y. M. C. A. building, including gymnasium, running track, restaurant, dormitories, also steam heating and refrigerating systems on 5th and Lamar Sts. Estimated cost $250,000. J. W. Clarkson, 1st Natl. Bank Bldg., Fort Worth, Archt.

Wis., Madison—The Dane County Bd., M. Sommers, Chn., Court House, is in the market for refrigeration equipment for cold storage plant at the county asylum.

Wis., Madison—H. Fauerbach, 938 Spaight St., is having plans prepared for the construction of a 5 story, 100 x 150 ft. hotel, including steam heating system, on Monrova St. Estimated cost $300,000. Balch & Lippert, Gay Bldg., Madison, Archts.

Wis., Madison—The New York Floral Co., 30 North Carroll St., F. Sholes, Mgr., plans the installation of a steam heating plant, conveyors, hoists, etc., in proposed greenhouses. Estimated cost $25,000. Engineer or architect not selected.

Wis., Milwaukee — The Dept. of Public Wks., R. E. Stoelting, Comr., will receive bids until June 15 for the construction of a gate house and laying of the distribution system in front of the Riverside Pumping Station.

Wis., Prairie du Chien—The Crawford County Levee and Drainage Dist., County Court House, has had plans prepared for the construction of 1,498,000 cu.yd. of river levee work; 1,265,000 cu.yd. bluff diversion; 278,200 cu.yd. drainage ditches; 22 mi. transmission lines; pumping plant, 80,000 g.p.m. capacity; 250 hp. pumps against 18 ft. head. Estimated cost $686,000. Central States Eng. Co., Muscatine, Ia., Engrs. Noted Nov. 21, 1922.

Wis., Rhinelander—The Rhinelander Electric Light Co., E. A. Forbes, Mgr. is in the market for steel gates for power house. Mead & Seastone, Journal Bldg., Madison, Engrs.

Wis., Wisconsin Rapids—The McKinnon Mfg. Co., 717 Grand Ave., manufacturer of automobile bodies, H. McKinnon, Purch. Agt., is in the market for electric motors.

Wyo., Casper—The city, M. M. Price, Box 1143, Clk., will hold an election June 26 to vote on a $275,000 bond issue for the construction of a 1,000,000 gal. storage reservoir and water main extensions, including pumping equipment, $200,000; sewers, storm sewer district, $75,000. F. S. Knittle, Box 1143, Engr.

Ont., Weston—The Toronto Free Hospital for Consumptives, E. L. Ruddy, 317 Spadina Ave., Toronto, Chn. of Bldg. Com., will soon award the contract for the construction of a central heating plant, including boiler house, pipe conduits, chimney, horizontal tubular boilers, piping, auxiliary equipment, radiation and domestic hot water equipment and installation, here. Estimated cost $100,000. M. F. Thomas, 229 College St., Toronto, Engr.

Ont., Hamilton—The Canadian Westinghouse Co., Traders' Bank Bldg., Toronto, is having plans prepared for the construction of a 2 or 3 story addition to factory for the manufacture of electrical machinery, here. Estimated cost $1,250,000. B. H. Prack, 50 Bay St., Toronto, Archt. Noted Apr. 24.

Ont., Hamilton—B. H. Prack, Archt., 50 Bay St., Toronto, is receiving bids for the construction of an 8 story, 115 x 135 ft. office building, including steam vacuum system, for J. E. Lister, 133 Glenfern Ave., here. Estimated cost $300,000. The architect will purchase electric passenger elevators.

Que., Montreal—The Agengee Laval, c/o M. Jean, 92 Notre Dame St., E., will soon be in the market for complete equipment for power house and transmission lines in the County of Laval.

Que., Montreal — The Central Quebec Power Co., Ltd., c/o J. M. Robertson, Engr., 20 St. Nicholas St., is in the market for complete electrical equipment for new business in the counties of Maskinonge, St. Maurice, L'Assomption, etc.

Que., Verdun — A. Hadley, City Hall, Engr., is receiving bids for transformers for electric light station and pumping equipment for waterworks. Estimated cost $10,000 and $12,000 respectively.

Australia, Melbourne—The State Electricity Comn. of Victoria, 22-32 William St., R. Liddelow, Secy., will receive bids until Aug. 31, for the supply, delivery, etc. of aluminum steel cored cable and accessories for the Morwell power scheme.

CONTRACT AWARDED

Ark., Pine Bluff—The Arkansas Light & Power Co. awarded the contract for the construction of the Remmel dam and hydro-electric power station on the Ouachita river between Malvern and Hot Springs to Ford, Bacon & Davis, Inc., 115 Broadway, New York, Consult. Engrs. Estimated cost $1,500,000. Noted May 29.

Calif., Los Angeles—The Erlanger Estate, c/o Schultze & Weaver, Archts., Pacific Mutual Bldg., awarded the contract for the construction of a theatre to the Scofield Eng. Co., Pacific Finance Bldg., Los Angeles. Estimated cost $500,000. Equipment detail not reported.

Calif., San Francisco—The St. Francis Hotel Co., Geary and Powell Sts., awarded the contract for the construction of a 5 story (ultimately 8 story) addition to its hotel on Post St. near Powell St. to the Lindgren Co., Monadnock Bldg., San Francisco. Estimated cost $1,000,000. Equipment detail not reported. Noted May 15.

Connecticut—The Dixie Gas Co., Hartford, awarded the contract for the construction of three 30 x 30 ft. gas stations at Sunsbury, New London, and on Windsor Ave., Hartford. Total estimated cost $80,000. The owner is in the market for three boilers for the Hartford station.

Ill., Freeport—The Arcade Mfg. Co., 1 Columbus Ave., will build by day labor, a 3 story, 66 x 196 ft. addition to its hardware and toy factory. Estimated cost $100,000. B. C. Trueblood, 161 Whistler St., Supt. of Constr. The owner is in the market for boiler equipment for boiler room.

Ill., Granite City — The Commonwealth Steel Co. will build by day labor, a 1 to 3 story steel foundry, including pattern shop, power house, 100 x 400 ft. foundry, 100 x 450 ft. core room with additional crane and 14 ovens, etc. Noted May 29.

Ky., Louisville—The Louisville Gas & Electric Co., 311 West Chestnut St., awarded the contract for furnishing the generators for the new $2,000,000 artificial gas plant on River Road, to the United Gas Improvement Co., Broad and Arch Sts., Philadelphia, Pa., $120,000.

Ky., Owensboro—The Hicks Hotel Co., Chicago, awarded the contract for the construction of a 4 story, 100 x 150 ft. hotel on 4th and Frederica Sts., here, to the Hoffman Constr. Co., Furniture Bldg., Evansville, Ind. Estimated cost $300,000. Equipment detail not reported.

Ky., Paducah—The Paducah Electric Co. awarded the contract for improvements and additions to power plant to Stone & Webster, Inc., 147 Milk St., Boston, Mass. Estimated cost $300,000. Noted May 29.

Mass., Boston—The Bay State Rd. Co., c/o Strickland, Blodgett & Law, Archts., 26 Pembroke Sq., awarded the contract for the construction of an 8 story, 105 x 140 ft. apartment at 91 Bay State Rd. to Chase & Gilbert, 185 Devonshire St., Boston. Estimated cost $600,000. Equipment detail not reported.

Mass., Boston—E. V. Earle & Sons, 200 Devonshire St., will build by day labor, an 8 story, 95 x 152 ft. stores and warehouse building at 49 Federal St. Estimated cost $750,000. Equipment detail not reported.

N. C., Davidson—The city awarded the contract for 27,000 ft. sewer mains, 20,180 ft. water mains, one 100,000 gal. reservoir, 1 pumping station and the installation of 2 service pumps and 1 fire pump, to Boyd, Higgins & Goforth, Charlotte, N. C., $31,000. The city will furnish all material except for reservoir and pump house.

S. C., Spartanburg—The Arcadia Mills awarded the contract for the construction of a 3 story, 100 x 300 ft. addition to its cotton mill, picker house, warehouse, boiler room and power plant to the Gallivan Bldg. Co., Greenville. Estimated cost $1,000,000.

Tenn., Memphis—R. York of York Lumber & Mfg. Co., 823 South Bellevue St., awarded the contract for the construction of a 5 story, 98 x 140 ft. office building on Madison and Manassas Sts. to the Blair Constr. Co., Randolph Bldg., Memphis. Estimated cost $500,000. Equipment detail not reported.

Tex., Galveston — The Texas Bank & Trust Co., 2202 D St., awarded the general contract for the construction of a 9 story bank building to the West Lake Constr. Co., First Natl. Bank, Fort Worth. H. B. Friedman, Engr. Estimated cost $515,000. Equipment detail not reported. Noted Jan. 30.

Tex., Houston—The Baptist Sanitarium, Lamar and Smith Sts., awarded the contract for the construction of an 8 story addition to its hospital to Henger & Chambers, Slaughter Bldg., Dallas. Estimated cost $325,000. Equipment detail not reported.

Wis., Neenah—The Valley Paper Mills, 145 Wisconsin Ave., awarded the contract for four 400 hp. boilers to the Wickes Boiler Co., Saginaw, Mich.; type E stokers to the Combustion Eng. Co., 43 Broadway, New York; fan and fan engine to the Clarige Fan Co., Kalamazoo, Mich. Noted Feb. 27.

Ont., Hanover—The city awarded the general contract for the construction of a waterworks system, including laying mains, reservoir, pumphouse, etc., to the Canadian Des Moines Steel Co., Inches Ave., Chatham; mechanical equipment, including pumps, motors, etc., to W. Kennedy & Sons, Owern Sound. Estimated cost $125,000. Noted May 1.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Structural and boiler rivets up 40c. and cold finished steel 20c. per 100 lb. in New York warehouses. Cotton waste, colored, 8@13c. per lb., against 7@12c., one month ago; rise due to curtailment of output in textile mills. Raw linseed oil stable in New York; $1.33, up from $1.10 in Cleveland and $1.37, advanced from $1.25 per gal. (5 bbl. lots) in Chicago. Slight rise in composition, 2-piece attachment plugs, conduit and couplings, during month.

Declines—Washed white wiping cloths at minimum of 10¼c. per lb. in New York. Babbitt metal lower in New York and Cleveland, following recent slump in non-ferrous metals. Downward trend in price of black and galvanized elbows.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		53c. per ft.
Common, 2½-in., 3-ply	$1.00 per ft. list less 40–5%	

	Air	
	First Grade	Second Grade
¾-in., 3-ply, per ft.	$0.33	$0.25

Steam—Discounts from List

First grade....40–5% Second grade....45% Third grade....50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10% Best grade..... 50–10–5%

LEATHER BELTING—List price per ply, 12-in. wide, per lin. ft. $2.88

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING—For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ¼ in.	$0.90
Asbestos for high-pressure steam, ¼ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		45%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72½%
	2-ply	75%

PORTLAND CEMENT—New York, $2.70@ $2.80 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.64 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	10.00@13.00	15.00	11.25
Colored	8.00@13.00	12.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13½ x 20½
Chicago	10.00	13.00
New York	10.25@11.25	....
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.16	$1.33	$1.37

WHITE AND RED LEAD—Base price in cents per pound:

	Red				White	
	Current		1 Year Ago		Current Dry or In Oil	1 Yr. Ago Dry or In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	14.50	16.00	12.25	13.75	14.50	12.25
25- and 50-lb. keg	14.75	16.25	12.50	14.00	14.75	12.50
12½-lb. keg	15.00	16.50	12.75	14.25	15.00	12.75
5-lb. cans	17.50	19.00	15.25	16.75	17.50	15.25
1-lb. cans	19.50	21.00	17.25	18.75	19.50	17.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅛ and smaller	40%	50–10%	60%
Tinned	40%	50–10%	4½c. per lb. net

Structural rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York.....$4.40 Chicago.....$3.75 Pittsburgh..$3.25@3.50

Boiler rivets, same sizes:

New York.....$4.50 Chicago.....$3.85 Pittsburgh..$3.35@3.60

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$52@55
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	27@32
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	31@36
Magnesite brick: 9-in. shapes	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	92.00@96.20
Silica brick: Chicago district	per M	52.00
Silica brick: Birmingham, Ala.	per M	51.00
Silica brick: Mt. Union, Pa.	per M	46.50
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	48@55
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	45@47
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	45@47
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	43@50
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@45
Chrome ore crude, 40@ 50%	net ton	25.50
Magnesite dead burn	net ton	39.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	55.00	41.00
(35% tin)	35.00	17.50	18.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.40	$3.90	$4.30
Flats, square and hexagons, per 100 lb. base	4.90	4.40	4.80

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	62	50½	¼ to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½ to 4	26	11
7 and 8	56	43½	4½ to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	¼ to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 52.00 (net)	$84.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	20%	10%
Coils to 1,000 ft.	25%	20%
1,000 to 5,000 ft.	30%	20-5%
5,000 ft. and over	35%	25%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
½	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
¾	79.20	84.95	13.00	14.49	8.18	8.78
1	112.06	122.19	19.26	21.46	10.65	11.42
1¼	151.62	165.31	25.65	28.33	14.76	15.78
1½	181.28	197.67	34.19	37.77	18.23	19.47
2	248.90	265.94	62.70	69.24	24.29	25.97
2½	385.50	420.48	102.58	11.33	34.71	37.10
3	504.29	548.81	273.40	302.12	51.66	55.63
3½	633.86	688.65	604.03	667.15	69.41	74.19
4	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.10	D. P. D. B.	$0.32
D. P. M. L.	.16	T. P. S. B.	.30
T. P. M. L.	.24	T. P. D. B.	.42
D. P. S. B.	.18		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.39	$1.00	$2.10
T. P. M. L.	.60	1.47	2.80
D. P. S. B.	.49	1.26	.....
T. P. S. B.	.92	2.10	.....
D. P. D. B.	.89	2.46	.....
T. P. D. B.	1.57	4.20	.....
T. P. to D. P. D. B.	1.05	2.88	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$23.00
No. 16 cotton reinforced heavy	29.00
No. 18 cotton reinforced light	19.50
No. 16 cotton reinforced light	22.50
No. 18 cotton Canvasite cord	17.00
No. 16 cotton Canvasite cord	19.25

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.20	3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.70
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.32	$0.37	120	75	$0.55	$0.60	60
15	.32	.37	120	100	.70	.75	24
25	.32	.37	120	150	.90	.95	24
40	.32	.37	120	200	1.15	1.25	24
50	.32	.37	120	300	1.75	1.85	24
60	.37	.42	120				
				500	2.50	2.65	12
				750	3.75	4.00	8
				1,000	4.25	4.50	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	.29
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.95	$10.30	$12.30	$19.80
12	10.50	13.40	14.80	25.50
10	14.40	16.70	19.00	33.00
8	20.10	22.58	24.90	42.10
6	.....	.....	37.60	.....
4	.....	.....	50.78	.....
2	.....	.....	14.80	.....
1	.....	.....	101.30	.....
0	.....	.....	122.00	.....
00	.....	.....	146.10	.....
000	.....	.....	176.00	.....
0000	.....	.....	212.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	20%
1-5th to standard package	25%
Standard package	35%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N E C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%